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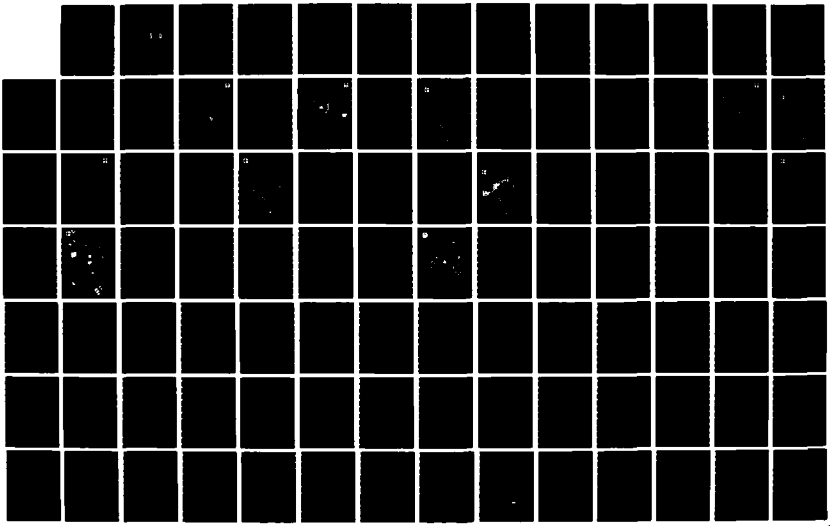

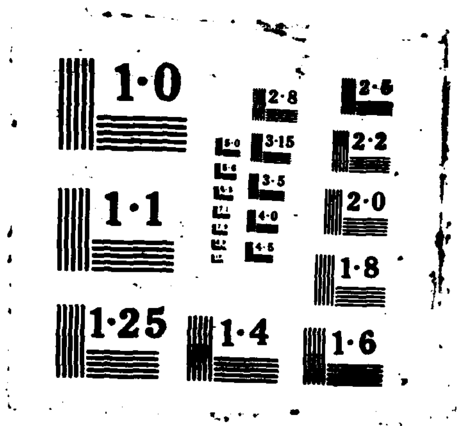
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INSTALLATION RESTORATION PROGRAM

PHASE II - CONFIRMATION/QUANTIFICATION

STAGE 1

LOWRY AIR FORCE BASE, COLORADO 80230

DAMES & MOORE
1550 NORTHWEST HIGHWAY
PARK RIDGE, ILLINOIS 60068

JANUARY 9, 1987

FINAL REPORT, AUGUST 31, 1984 TO SEPTEMBER 18, 1985

PREPARED FOR

HEADQUARTERS AIR TRAINING COMMAND
COMMAND SURGEON'S OFFICE (HQ ATC/SGPB)
BIOENVIRONMENTAL ENGINEERING DIVISION
RANDOLPH AIR FORCE BASE, TEXAS 78150

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

DISCLAIMER NOTICE

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 1

FINAL REPORT

FOR

LOWRY AIR FORCE BASE, COLORADO 80230

AIR TRAINING COMMAND
RANDOLPH AFB, TEXAS 78150

JANUARY 9, 1987

PREPARED BY

DAMES & MOORE
1550 NORTHWEST HIGHWAY
PARK RIDGE, ILLINOIS 60068

USAF CONTRACT NO. F33615-83-D-4002, DELIVERY ORDER NO. 0026

USAFOEHL TECHNICAL PROGRAM MANAGER
Capt Maria LaMagna

USAF OCCUPATIONAL & ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
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The Lowry AFB Phase II, Stage 1 field evaluation of the IRP investigated four areas: the fire training zone, the sanitary landfill zone, the old jet fuel yard area, and the auto hobby shop. The field investigation consisted of installing and sampling a total of five monitoring wells and drilling and sampling four soil borings.

Ground water is available as a water table aquifer in the surficial unconsolidated deposits at Lowry AFB and in the interbedded sandstone and siltstone of the Denver Formation. The Denver Water Board provides the water supply for Lowry AFB, but there are wells in use within a mile of the base boundaries.

No primary drinking water standards were found to be exceeded at Lowry AFB during this investigation, but parameters for which there are no standards indicated some ground water contamination has occurred at the base. The soil and ground water at the fire training area and the old jet fuel yard have been contaminated, probably by fuel. The auto hobby shop has apparently been affected by oil and grease in surface soils only. The landfill zone shows limited contamination with TOC, TOX, and oil and grease.

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PREFACE

As part of the U.S. Air Force Installation Restoration Program (IRP), investigations were undertaken at four areas on Lowry Air Force Base, Colorado, to determine whether hazardous material contamination is present. This report, prepared by Dames & Moore under Contract No. F33615-83-D-4002, Order 0026, presents the results of the Phase II, Stage 1 IRP investigations. The period of work reported on herein was October 1984 through September 1985. The field investigations were directed by Dr. Kenneth J. Stimpfl. Mr. Larry Cope, Staff Hydrogeologist, supervised field activities, and Mr. Steve Werner, Hydrology Technician, supervised the soil sampling and well installation. Additional assistance in data compilation and analysis and report preparation was provided by Dr. M. Carol McCartney, Project Hydrogeologist, and Ms. Carol J. Scholl, Staff Geologist. Mr. Richard H. Pearl, Senior Hydrologist, provided regional and local hydrogeologic analysis and review. Capt Maria La Magna, Technical Services Division, USAF Occupational and Environmental Health Laboratory (OEHL), was the Technical Manager.

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SUMMARY

Lowry Air Force Base (AFB) is located in the northeast quadrant of Colorado and is surrounded by the cities of Denver and Aurora. The base is situated on the western edge of the Great Plains physiographic province in a gently rolling to flat area underlain by thin, unconsolidated deposits of sand and loess and thick sedimentary sequences over Precambrian age rock. The base has been in operation since 1937; the host organization is the 3400th Technical Training Wing.

The Phase II, Stage 1 field evaluation of the Installation Restoration Program (IRP) consisted of investigations at the following four areas:

- o Area 1, Fire Training Zone: Sites FT-1 and FT-2;
- o Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1;
- o Area 3, Old Jet Fuel Yard Area: Site SP-1; and
- o Area 4, Auto Hobby Shop: Site S-5.

The locations of the four areas on Lowry AFB are shown in Plate 3. The locations of the monitoring wells and soil borings are shown in Plates 11 through 13.

The field investigation consisted of the following activities:

- o Installation and sampling of one monitoring well at Area 1, three monitoring wells at Area 2, and one monitoring well at Area 3; and

- o Drilling and sampling two boreholes at Area 1 and two boreholes at Area 4.

The ground water samples were analyzed for oil and grease, total organic carbon (TOC), and total organic halogens (TOX) in all the wells; for lead at Site FT-1 (Area 1) and Area 2; and for four additional metals (cadmium, chromium, nickel and silver), phenolics, and eight pesticides at Area 2. Soil samples were analyzed for percent moisture, oil and grease, TOC, and TOX at all areas; and for lead at Areas 1 and 4.

Ground water occurs under water table conditions in the surficial unconsolidated deposits at Lowry AFB and under water table and artesian conditions in the interbedded sandstone and siltstone of the Denver Formation. These two aquifers are believed to be hydraulically connected in the vicinity of the base. Successively deeper and older aquifers under the base are the Arapahoe Formation and the Laramie-Fox Hills Formation. Ground water flow in the upper aquifers is generally from southeast to northwest, paralleling the surface drainage. Ground water quality in the area is generally good and is suitable for most municipal and industrial purposes, but iron (0.04 to 6.1 mg/L) and total dissolved solids (49 to

905 mg/L) are elevated. Surface water quality varies areally across the base with elevated total dissolved solids in the part of Westerly Creek that drains the southeast portion of the base. There is a potential for ground water contamination within the surficial aquifer at Lowry AFB because the water table is shallow and the soils are permeable.

A well established water distribution system exists in the Denver metropolitan area. In the Lowry AFB area, water users obtain their water from either the Denver Water Board or the City of Aurora. Lowry AFB is served by the Denver Water Board. Even though domestic water is available to all homes and businesses, in the metropolitan area some owners have drilled individual water wells. These wells are primarily used for lawn irrigation purposes. A number of registered water wells are found within a mile of Lowry AFB.

No Primary Drinking Water Standards were found to be exceeded at Lowry AFB during this investigation, but parameters for which there are no standards indicated some ground water contamination has occurred at the base. In particular, the soil and ground water at Areas 1 and 3 have been contaminated, probably by fuel. Area 4 has oil and grease in surface soils only. At Area 2, minor ground water contamination was found.

Further work is recommended to confirm the magnitude of contamination beneath Lowry AFB and to attempt to establish the distance and direction of contaminant movement. Additional wells and analyses of soil and ground water are recommended for Areas 1, 2, and 3. Removal of contaminated soil is recommended for Area 4.

The following summarizes our recommendations and rationale for further investigations:

Area	Recommendation	Rationale
	CATEGORY II SITES	
Area 1 Fire Training Zone Sites FT-1 and FT-2	Install five monitoring wells and collect two soil samples during drilling.	To determine the local ground water flow regime and its relationship to regional ground water flow. To assist in characterizing background water quality for this area, and to determine whether a contaminant plume is migrating from this area. Soil will be analyzed to determine whether black sticky sand can be attributed to fire training activity.

Area	Recommendation	Rationale
	CATEGORY II SITES (continued)	
Area 2 Sanitary Landfill Zone Sites D-1, D-2, and T-1	Install five monitoring wells.	To determine the local ground water flow regime and its relationship to regional ground water flow. To assist in characterizing background water quality for this area, and to determine whether a contaminant plume is migrating from this area.
Area 3 Old Jet Fuel Yard Site SP-1	Install three monitoring wells.	To determine the local ground water flow regime and its relationship to regional ground water flow. To assist in characterizing background water quality for this area, and to determine whether a contaminant plume is migrating from this area.
General Locations SW, SE, and NE Areas of Lowry AFB	Install three monitoring wells.	To assist in constructing a potentiometric map of the alluvial aquifer and to characterize water quality for the contaminants of interest for the area.
Areas 1, 2, and 3 and Background Sites FT-1, FT-2, D-1, D-2, T-1, and SP-1	Analyze three existing wells and new monitoring wells for TDS, specific conductance, iron, sulfates, chlorides, manganese, pH, temperature, lead, oil and grease, purgeable aromatics (USEPA Method 602) plus xylene, and purgeable halocarbons (USEPA Method 601). Analyze two soil samples from Area 1 for oil and grease, petroleum hydrocarbons, and phenol.	To confirm the analyses of this investigation, and to elucidate the nature of hydrocarbon and halocarbon contaminants.
	CATEGORY III SITE	
Area 4 Auto Hobby Shop Site S-5	Remove contaminated soils from area surrounding underground waste oil tank.	This area lies at the boundary of the Standard Project Flood; therefore, quick removal of contaminated soils is warranted.

I. INTRODUCTION

A. BACKGROUND

The U.S. Department of Defense (DOD) initiated the Installation Restoration Program (IRP) to investigate and mitigate any environmental contamination that may be present at DOD facilities as a result of handling or disposing of hazardous materials. The IRP was issued in 1981 as Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5. The U.S. Air Force (USAF) implemented DEQPPM 81-5 in 1982 as a four-phased program:

Phase I	Program Identification/Records Search
Phase II	Program Confirmation and Quantification (Several stages, as necessitated by field and laboratory results)
Phase III	Technology Base Development
Phase IV	Corrective Action

For Lowry Air Force Base (AFB), Denver, Colorado, Phase I was completed by Engineering-Science (1983). Dames & Moore was retained by the USAF under Contract Number F33615-83-D-4002, Order 0026, to conduct the Phase II, Stage 1 field evaluation. The location of Lowry AFB is provided on the Regional Location Map, Plate 1.

This report presents the results of Dames & Moore's field and laboratory investigations in the vicinity of hazardous waste disposal and handling areas at Lowry AFB. Chemical analyses were performed by UBTL, Inc., of Salt Lake City, Utah, as subcontractor to Dames & Moore.

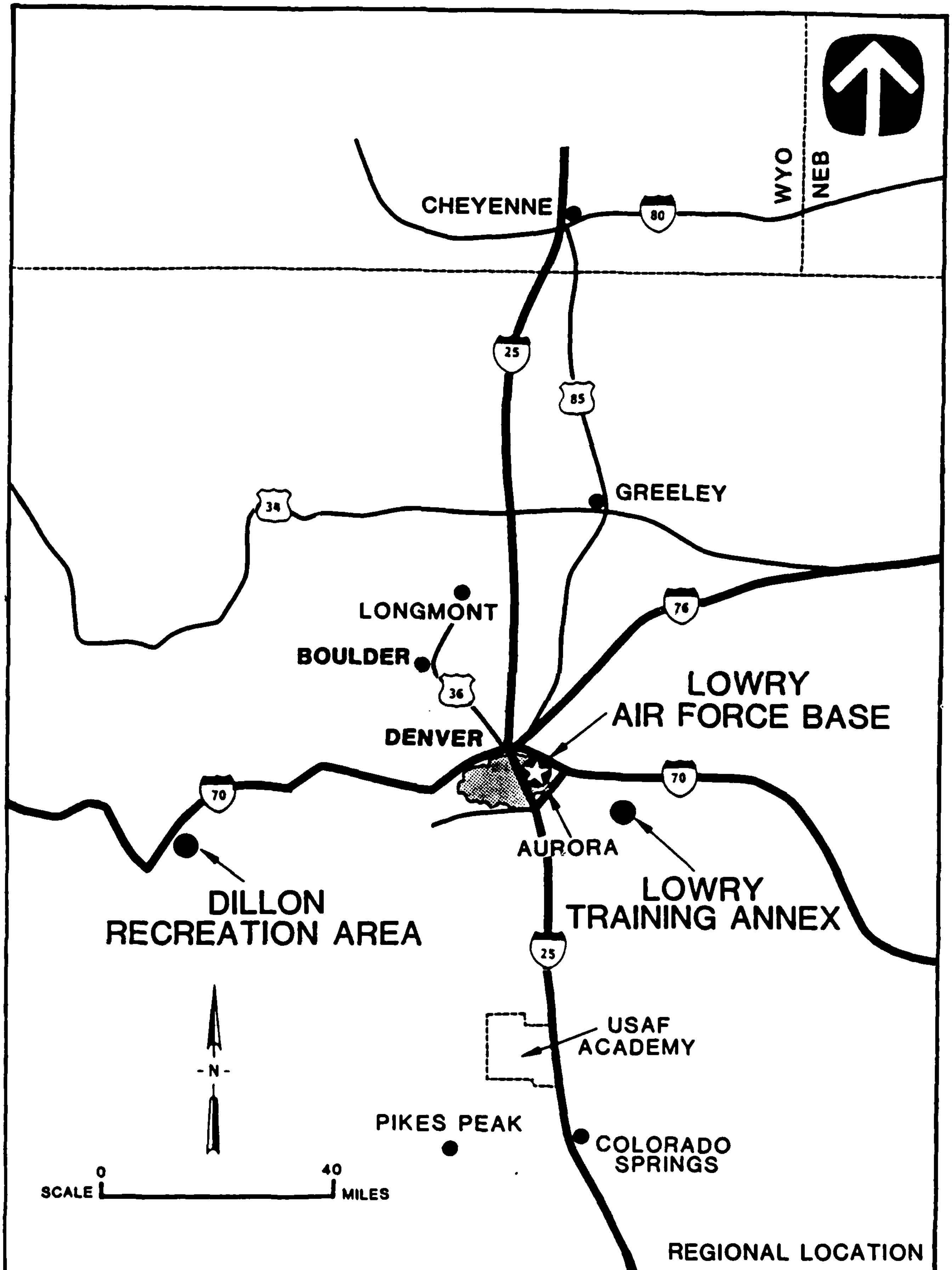
B. PURPOSE AND SCOPE

As set forth in the Contract (Appendix B), the purposes of the field evaluation portion of Phase II, Stage 1 of the IRP were to:

1. Determine whether environmental contamination has resulted from material handling or waste disposal practices at Lowry AFB;

2. Determine or estimate the magnitude and extent of contamination, if contamination was found; and

3. Recommend any additional investigations and their attendant costs necessary to identify the magnitude, extent, and direction of movement of discovered contaminants.



ADAPTED FROM: COMMERCIAL HIGHWAY MAP
SOURCE: ES ENGINEERING-SCIENCE, 1983

REGIONAL LOCATION
LOWRY AFB
Dames & Moore

PLATE I

The scope of work as outlined for Phase II, Stage 1 of the IRP consisted of the following activities:

1. Drilling, soil sampling, and geologically logging nine borings to depths ranging from 11.5 to 40 feet at four locations as identified in Section I.D, Description of Areas;

2. Installing and developing a monitoring well in five of these borings;

3. Analyzing selected soil samples from the borings for percent moisture, oil and grease, total organic carbon (TOC), total organic halogens (TOX), and lead;

4. Analyzing selected ground water samples for oil and grease, TOC, TOX, lead, cadmium, chromium, nickel, silver, phenolics, and eight pesticides (aldrin, chlordane, dieldrin, DDT, endrin, endrin aldehyde, heptachlor, and lindane); and

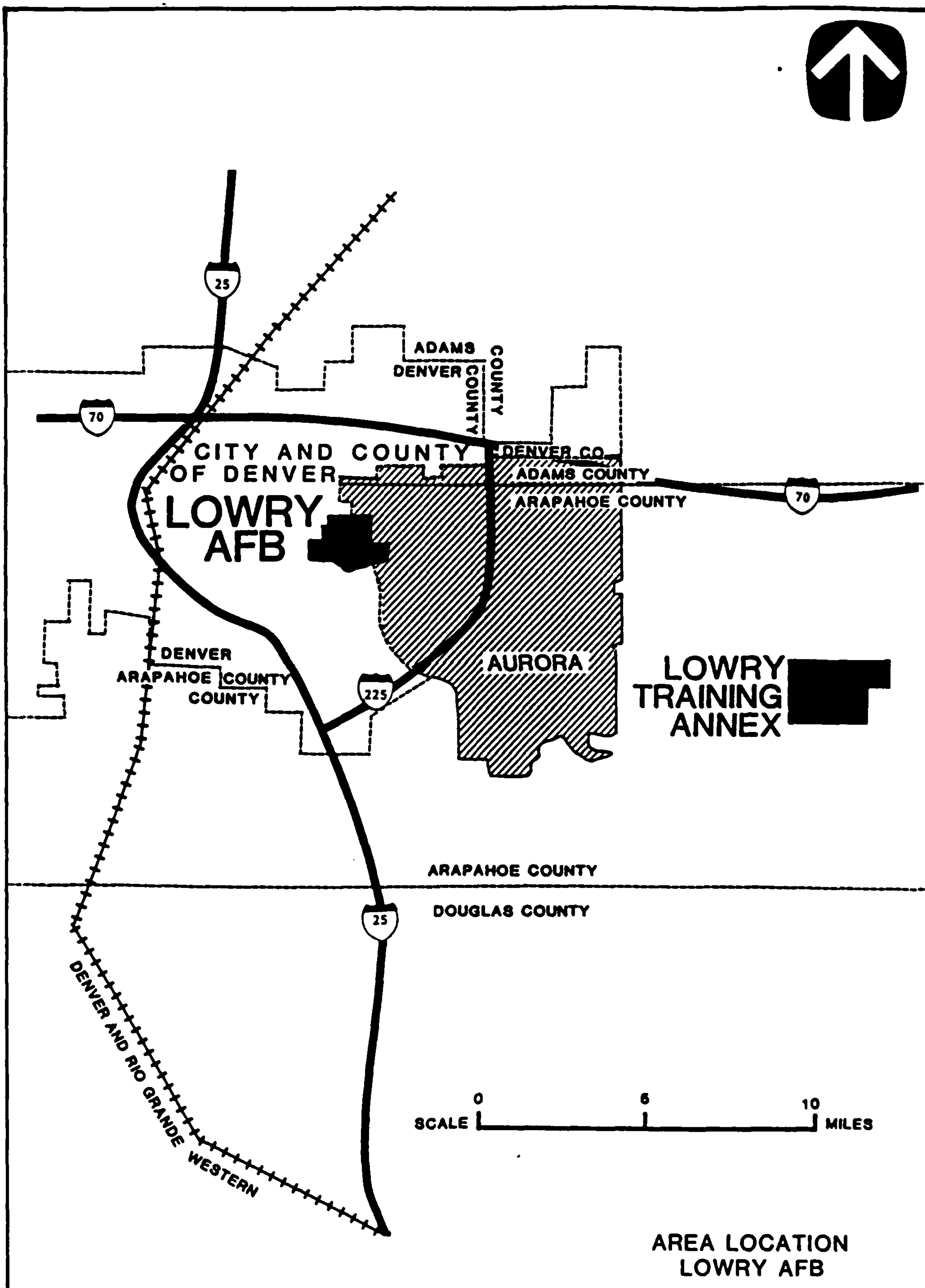
5. Preparing a report, which presents our findings and recommendations.

Field work began in October 1984 and continued through November 1984, with one repeat sample being collected in September 1985.

C. HISTORY OF LOWRY AFB AND WASTE DISPOSAL OPERATIONS

Lowry AFB is located within the cities of Denver and Aurora in the northeastern quadrant of Colorado (Plate 2). The base was established in August 1937 on the site of the Agnes Phipps Memorial Sanitarium. In 1941, 960 adjoining acres were donated by the City and County of Denver. During World War II, photography, armament, and B-29 crew training were the missions of Lowry AFB. From 1954 through 1958, Lowry AFB hosted the Air Force Academy, and from 1961 through 1965 it was the host base for 18 Titan missile silos located off base. The present host at the base is the 3400th Technical Training Wing, whose primary mission is military and technical training (Engineering-Science, 1983).

Hazardous wastes and materials have been used and generated at Lowry AFB since early 1940 in industrial operations (shops), pesticide use, fuels management, and fire training. These activities generated approximately 126,000 gallons per year of photographic chemicals and about 12,000 gallons per year of waste oils, solvents, paints, and paint thinners (Engineering-Science, 1983). Other wastes generated by the base include low-level radioactive waste, waste fuel and oil, and pesticides. Waste photographic chemicals have been discharged to the sanitary sewer. In the past, the hazardous wastes have been disposed of by one or more of the following methods:



AREA LOCATION
LOWRY AFB

Dames & Moore

SOURCE: ES ENGINEERING-SCIENCE, 1983.

PLATE 2

- o Codisposal with general refuse at the base sanitary landfill (Area 2, Site D-1);
- o Incineration through fire department training exercises; and/or
- o Discharge to the sanitary sewer or storm drain, recycling, or removal by contractor.

Since 1980, hazardous wastes have been accumulated on base before being delivered to the Defense Property Disposal Office (DPDO) at the Rocky Mountain Arsenal for disposal (Engineering-Science, 1983).

D. DESCRIPTION OF AREAS

Engineering-Science (1983) rated nine out of 23 sites identified as having a potential for environmental contamination. Of the nine, the following four areas were considered to have the greatest potential for environmental impact and were investigated during Phase II, Stage 1:

- o Area 1, Fire Training Zone: Sites FT-1 and FT-2;
- o Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1;
- o Area 3, Old Jet Fuel Yard Area: Site SP-1; and
- o Area 4, Auto Hobby Shop: Site S-5.

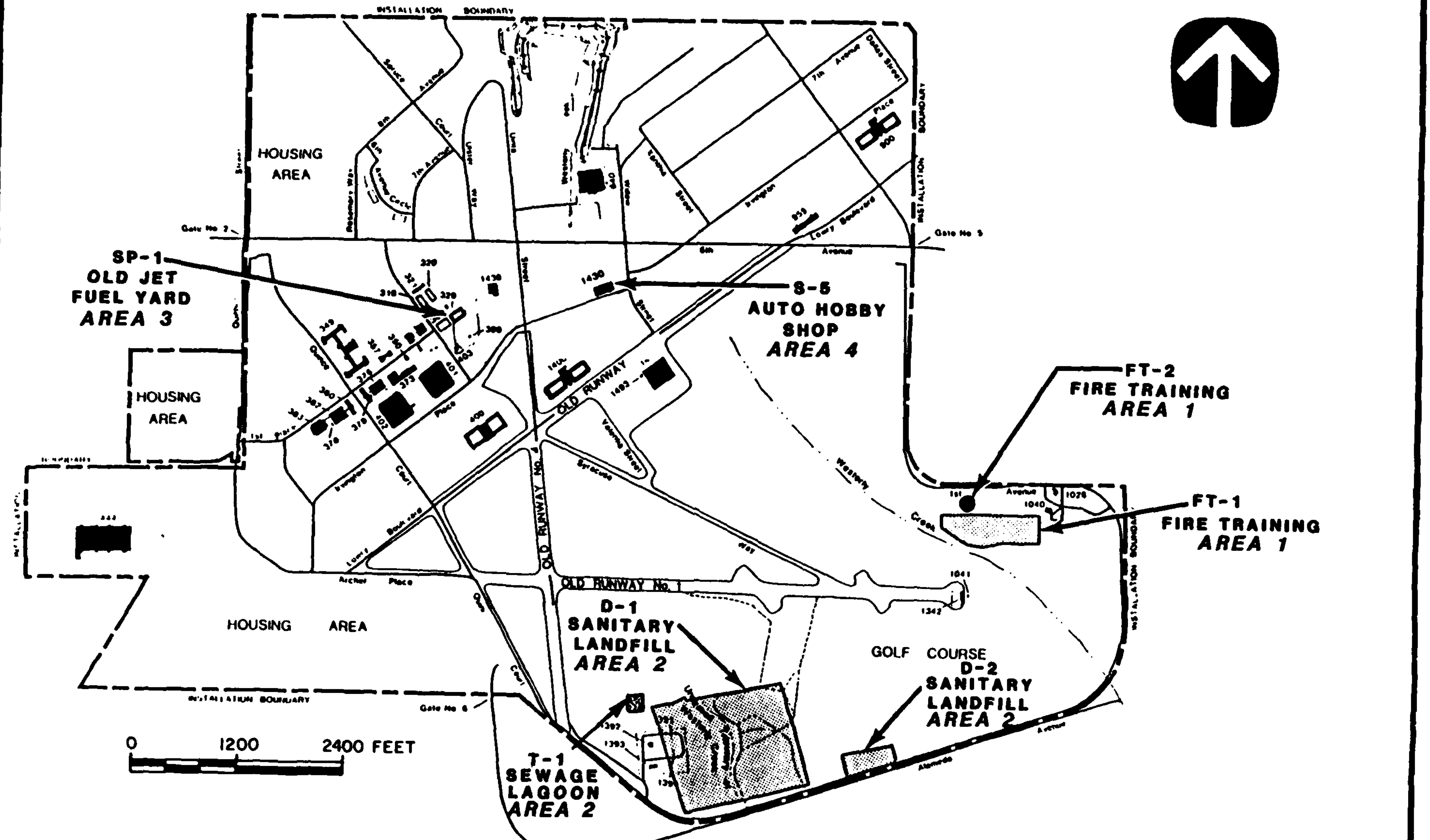
These areas are shown in Plate 3 and are described below.

1. Area 1, Fire Training Zone: Sites FT-1 and FT-2

The fire training area is located in the southeast part of the base just west of Havana Street. Westerly Creek, an intermittent northwest flowing stream, flows along the west side of the area.

Site FT-1, utilized from 1946 to 1965, is an area in which contaminated oils, fuels, and waste solvents were stored in drums and burned in a bermed area during fire training exercises. From 1946 to 1960, approximately 10,000 to 25,000 gallons per week were incinerated in this area; from 1961 to 1965, 500 gallons were ignited once per week. Unconsumed waste fuel remained in the area after each fire training exercise.

At Site FT-2, the fire training site from 1965 to 1980, a small pit was used to burn 5 gallons of clean JP-4 fuel once every 3 months. No obvious remnants of fuel remain at Sites FT-1 or FT-2, but Site FT-1 does not support abundant vegetation. A potential for ground water contamination exists in the vicinity due to the permeable nature of the soils and the shallow depth to the water table.



DRAWING REFERENCE:
TITLED: DISPOSAL SITES, SPILL SITE, FIRE TRAINING AREAS, AND STORAGE SITES
FOR: LOWRY AIR FORCE BASE
BY: ES ENGINEERING-SCIENCE
DATE: 1983

SITES INVESTIGATED DURING PHASE II, STAGE 1, IRP LOWRY AFB

Dames & Moore

PLATE 3

2. Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1

At Site D-1, near the southern boundary of the base, general refuse was disposed of in trenches excavated by a dragline to a depth of 12 to 15 feet. The trenches were normally excavated to a depth below the water table. The wastes disposed of in the trenches were covered daily with local soil. Between 1948 and 1979, the materials disposed of included both general refuse and other materials. Waste solvents, empty pesticide containers, paint thinners, cutting oils, and spent acids were disposed of in drums at the site during the 1950s and 1960s. A suspected low-level radioactive waste disposal site, RD-1, located within Site D-1, is reported to contain electron tubes, a low-level radioactive waste. This material is suspected to have been buried within a concrete vault made from portions of a storm drain under 12 to 15 feet of fill at Site D-1. The major portion of D-1 is now closed and covered with several feet of soil. The northeastern edge of the site is currently used for disposal of construction rubble. Although there is no evidence of leachate, contaminated surface water, or vegetative stress, the potential for contamination exists at this site because of the presence of small quantities of hazardous waste at the site and the practice of locating trenches within the saturated zone of permeable soils.

Both general refuse and construction rubble were deposited in Site D-2, a 100- by 500-foot depression in the southeast corner of the base now occupied by the golf course. Six to 8 feet of fill were buried at a depth several feet above the water table. The fill is now covered with several feet of local soil and has been revegetated. No visual evidence of contamination exists. Although there is no record of hazardous wastes having been buried at this site, the possibility of disposal of minor quantities of hazardous substances from industrial shop operations exists. For this reason, and due to the proximity of this site to the installation boundary, as well as the nature of the soils and depth to ground water, this site warranted investigation as a zone.

Located just to the northwest of Site D-1 is a non-discharging (evaporation type) sewage lagoon (Site T-1). Due to the nature of this lagoon, it does not have a National Pollutant Discharge Elimination System (NPDES) permit. Although the wastes disposed of in the stabilization pond are of a generally nonhazardous nature, the pond was also investigated due to possible environmental contamination.

3. Area 3, Old Jet Fuel Yard Area: Site SP-1

This area, located near Buildings 329 and 369, was the site of spills of jet fuel during the 1950s and early 1960s. While no major spills were reported, numerous small spills occurred during loading and unloading of aircraft at the fuel yard. Due to the permeability of the soils and the high water table, a potential for contamination exists at this site.

4. Area 4, Auto Hobby Shop: Site S-5

An underground waste oil storage tank is located at Site S-5, the Auto Hobby Shop. Although no leaks have been reported, an incidence of overfilling this tank was recalled subsequent to the issuance of the Phase I report. Therefore, this site was included in the Phase II investigation.

E. IDENTIFICATION OF POLLUTANTS SAMPLED

Based on the wastes present in the above areas, potential contaminants include organic carbons, organic halogens, phenols, pesticides, and the heavy metals — nickel, lead, cadmium, chromium, and silver. These analyzed parameters are listed in Table 1. Ground water samples were measured in the field for temperature, pH, and specific conductance. Laboratory analyses were provided by UBTL, Inc. of Salt Lake City, Utah, as a subcontractor to Dames & Moore.

F. IDENTIFICATION OF THE FIELD TEAM

The field investigations required for Phase II, Stage 1, were accomplished under the general direction of Dr. Kenneth J. Stimpfl. Mr. Larry Cope, Staff Hydrogeologist, supervised the borehole drilling and monitoring well installation with field assistance from Mr. Steve Werner, Hydrology Technician. Additional assistance in data compilation and analysis and report preparation was provided by Dr. M. Carol McCartney, Project Hydrogeologist, and Ms. Carol J. Scholl, Staff Geologist. Mr. Richard H. Pearl, Senior Hydrologist, provided regional and local hydrologic analysis and review. Drilling services were provided by Custom Auger Drilling Services, Inc., Denver, Colorado, as a subcontractor to Dames & Moore. Appendix I contains biographies of key personnel.

TABLE 1

PARAMETERS, LIMITS OF DETECTION FOR SOIL AND GROUND WATER ANALYSES, AND WATER QUALITY CRITERIA

PARAMETER	LIMIT OF DETECTION, SOIL (μg/g)	LIMIT OF DETECTION, WATER (μg/L)	PRIMARY DRINKING WATER STANDARD (μg/L)	ANALYSES PERFORMED: AREA 1 FIRE TRAINING ZONE	AREA 2 SANITARY LANDFILL ZONE	AREA 3 OLD JET FUEL YARD	AREA 4 AUTO HOBBY SHOP
Oil and grease	7	500	NE	1w, 12s	3w	1w, 4s	6s
TOC	5	1000	NE	1w, 12s	3w	1w, 4s	6s
TOX	5	10	NE	1w, 12s	3w	1w, 4s	6s
Phenols	-	10	NE		3w		
Lead	0.010 mg/L*	0.010 mg/L	50	1w, 12s	3w		6s
Cadmium	0.010 mg/L*	0.010 mg/L	10		3w		
Chromium	0.050 mg/L*	0.050 mg/L	50		3w		
Nickel	-	0.050 mg/L	NE		3w		
Silver	0.010 mg/L*	0.010 mg/L	50		3w		
Aldrin	-	0.01	NE		3w		
Chlordane	-	0.02	NE		3w		
Dieldrin	-	0.01	NE		3w		
DDT isomers	-	0.05	NE		3w		
Endrin	0.02 μg/L*	0.02	0.2		3w		
Endrin aldehyde	-	0.02	NE		3w		
Heptachlor	-	0.01	NE		3w		
Lindane	0.01 μg/L*	0.01	4.0		3w		

*EP Toxicity extraction.

Note: μg/g = micrograms per gram
μg/L = micrograms per liter
NE = no criterion established
w = analysis of water
s = analysis of soil

II. ENVIRONMENTAL SETTING

A. PHYSICAL GEOGRAPHY

Lowry AFB, located in all or parts of Sections 3, 4, 8, 9, and 10, T4S, R67W, 6th PM, occupies 1860 acres within the cities of Denver and Aurora in Denver and Arapahoe counties, Colorado. The area around the base is urbanized, being residential or commercial in use. No changes in land use surrounding Lowry AFB are anticipated.

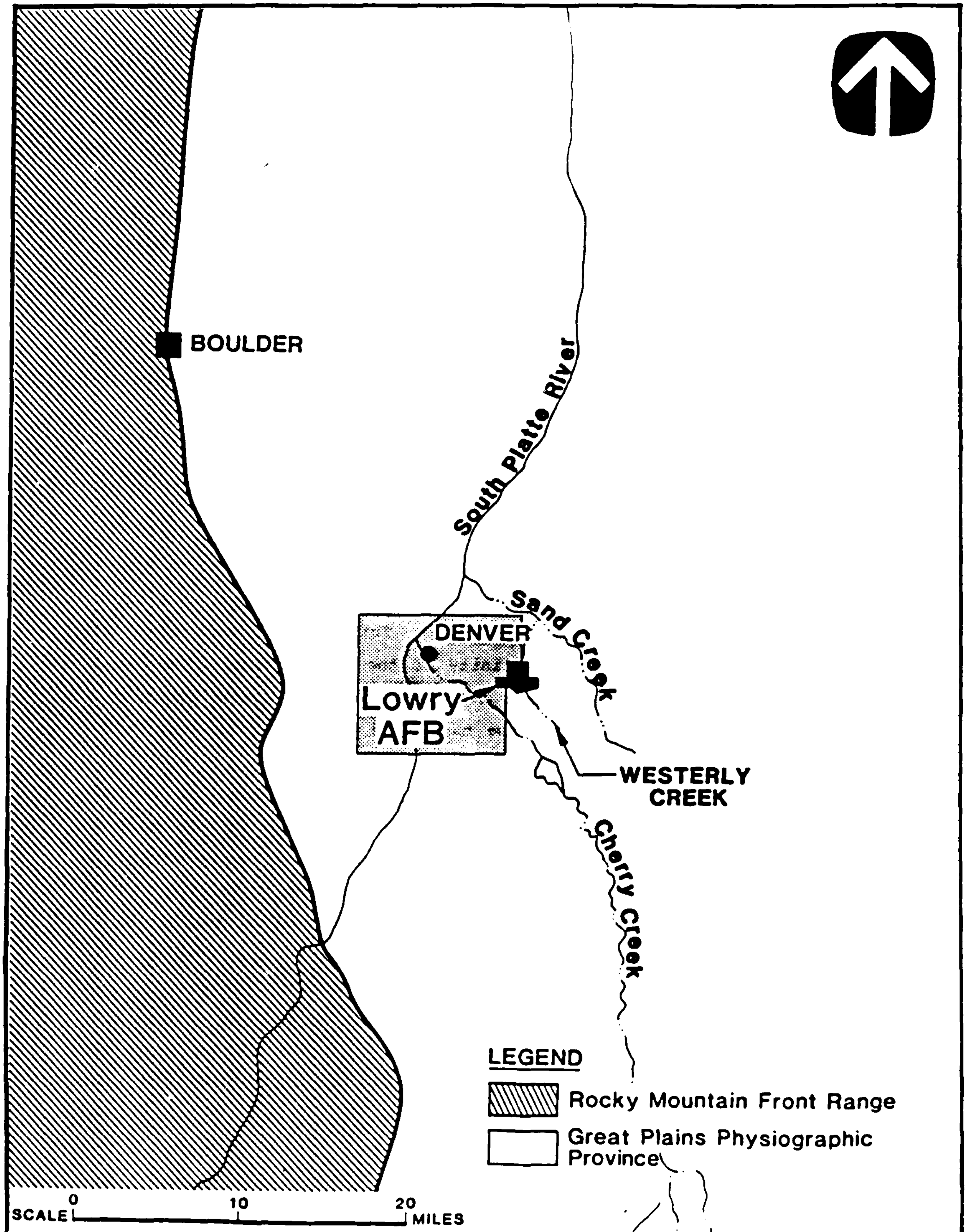
The base is located approximately 20 miles east of the Front Range of the Rocky Mountains along the western edge of the Great Plains physiographic province (Plate 4). The topography at Lowry AFB is gently rolling to flat and varies from 5350 feet above mean sea level (MSL) at the northern edge of the base to 5450 feet MSL along the eastern edge (Plate 5). A small north-south trending hill is located along the west-central border of the base.

The base is drained by Westerly Creek and by the City of Denver's storm sewers. Water in both drainages ultimately flows into the north flowing South Platte River. Westerly Creek, a north flowing stream that heads just southeast of the base, is tributary to Sand Creek, which is tributary to the South Platte River (Plate 4). Cherry Creek, a major tributary to the South Platte River in the Denver area, is located approximately 1½ miles south of the base. No surface waters from the base flow into Cherry Creek.

The normal annual precipitation in the area is 15.5 inches. The climate is semiarid, and yearly net precipitation is approximately -30 inches. The potential for contaminant migration in the area is reduced by this low net precipitation. Normal temperature ranges are a low of 16°F and a high of 43°F in January and a low of 59°F and a high of 86°F in July (Engineering-Science, 1983).

B. REGIONAL GEOLOGY AND HYDROGEOLOGY

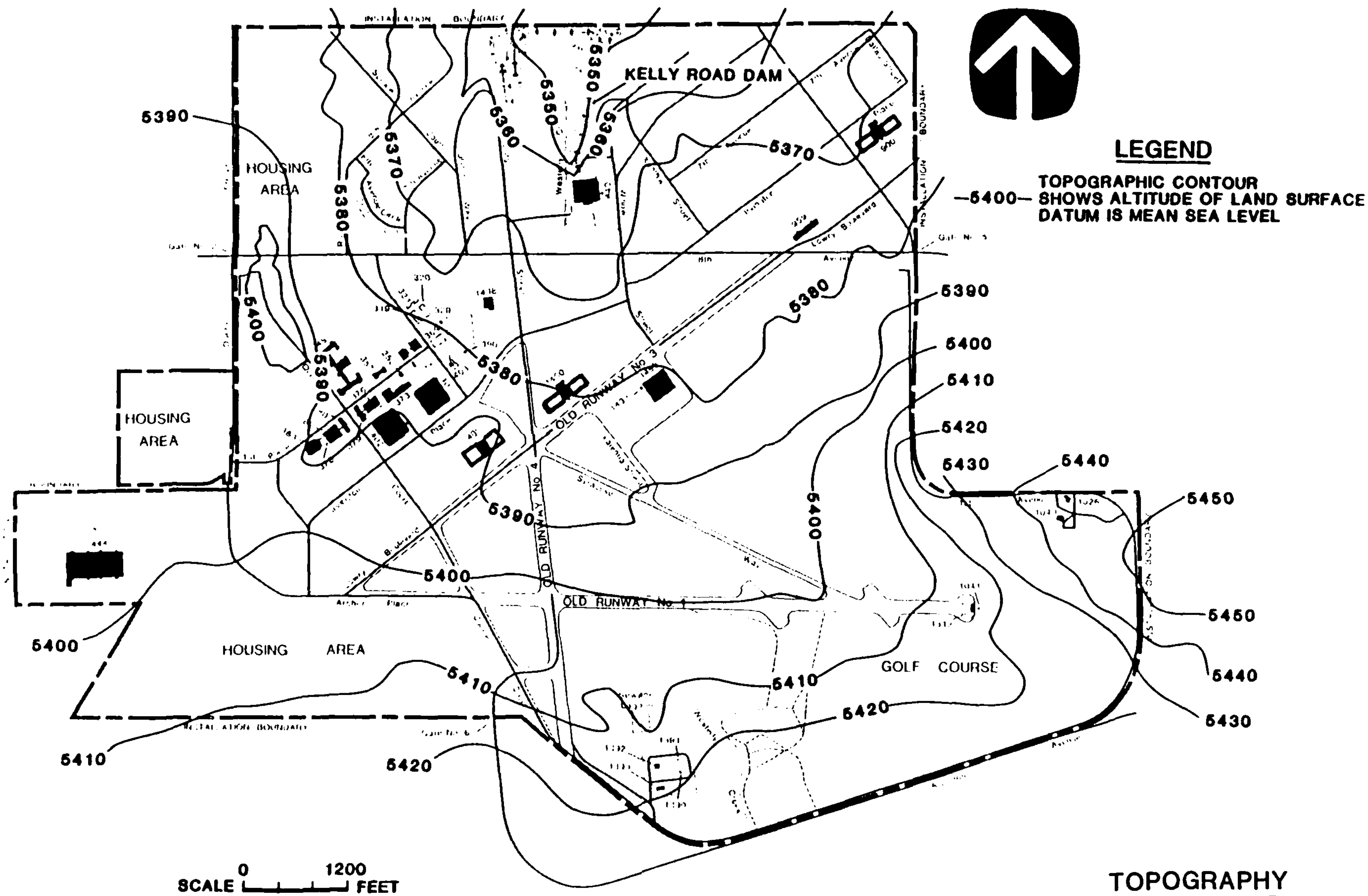
The following discussion is taken from the following sources: Engineering-Science (1983), Hillier et al. (1983), Robson (1985), and Robson et al. (1981a and 1981b).



PHYSIOGRAPHIC DIVISIONS
LOWRY AFB

SOURCE: ES ENGINEERING-SCIENCE, 1983.

Dames & Moore



TOPOGRAPHY
LOWRY AFB

SOURCE: ES ENGINEERING-SCIENCE, 1983.

Dames & Moore

PLATE 5

Lowry AFB is located along the western side of the Denver Basin, a north trending geological structure. The Denver Basin, which extends from near Colorado Springs in the south to near Greeley in the north, is bounded on the west by the Front Range of the Rocky Mountains and on the east by the High Plains of eastern Colorado (Plate 6). Geographically, Lowry AFB is located along the western side of the basin; however, due to the unique shape of the basin, geologically the base is located approximately over the axis of the basin (Plate 6). The basin is asymmetrical in shape, with the bedrock formations along the western side having much steeper dips than those along the eastern side. For example, rocks exposed at the surface along the mountain front a few miles west of Denver are found at a depth of 15,000 feet under Denver. Some of the formations exposed along the west side of the basin do not crop out along the east side.

The Denver Basin is composed of rocks ranging in age from Precambrian to Recent and consist of granitic, metamorphic, and sedimentary rocks. The sedimentary formations overlying the basal Precambrian age granitic and metamorphic rocks range in age from Pennsylvanian to Recent. These rocks primarily are composed of sandstones, shales, siltstones, and claystones. Due to their great depth, the Precambrian age rocks and the Pennsylvanian to upper Cretaceous age formations are not considered important ground water aquifers in most of the basin. Throughout most of the basin the Pierre shale, due to its low permeability and great thickness (up to 6500 feet), is considered to be the base of the bedrock aquifer system. Overlying the Pierre shale are four important aquifers and one other formation that is not an important source of water in the Denver area. In ascending order, these formations are the Fox Hills sandstone, Laramie Formation, Arapahoe Formation, Denver Formation, and Dawson Formation. The Late Cretaceous Fox Hills sandstone, approximately 200 feet, consists of shale, shaley sandstone, and sandstone. The Laramie Formation, 600 to 650 feet thick, consists of sand, clay, and shale with many coal seams. Next are the Late Cretaceous age Arapahoe Formation, the Denver Formation, and the Tertiary age Dawson Arkose. These formations include 1000 to 1200 feet of sand, clay, shale, and sandstone with some coal seams. In addition, Recent age alluvial aquifers occur as saturated sand and gravel in present and ancestral stream valleys and terraces. These aquifers, as well as the three bedrock aquifers, provide water for urban, suburban, and rural uses. A description of the lithology and water-bearing properties of these formations is presented in Table 2. Throughout the rest of the report, only these upper aquifers will be discussed. The Dawson Arkose, which occurs only in the south-central section of the basin, is not present in the Lowry AFB area.

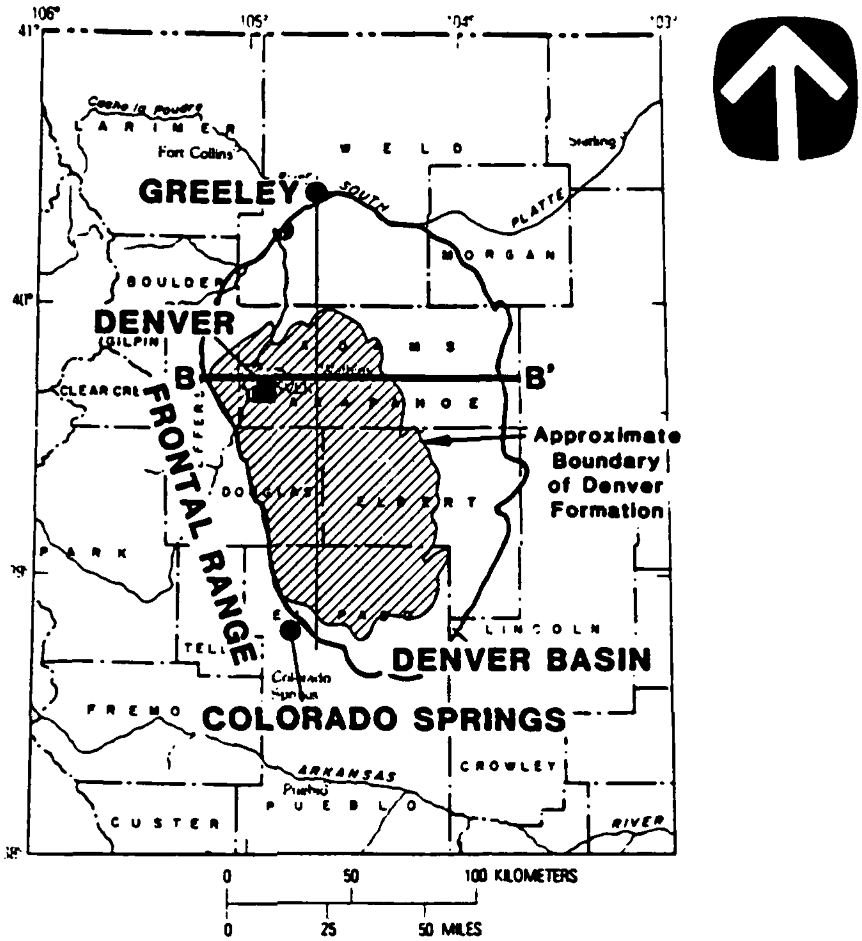


PLATE 6A MAP OF COLORADO SHOWING LOCATION OF DENVER BASIN

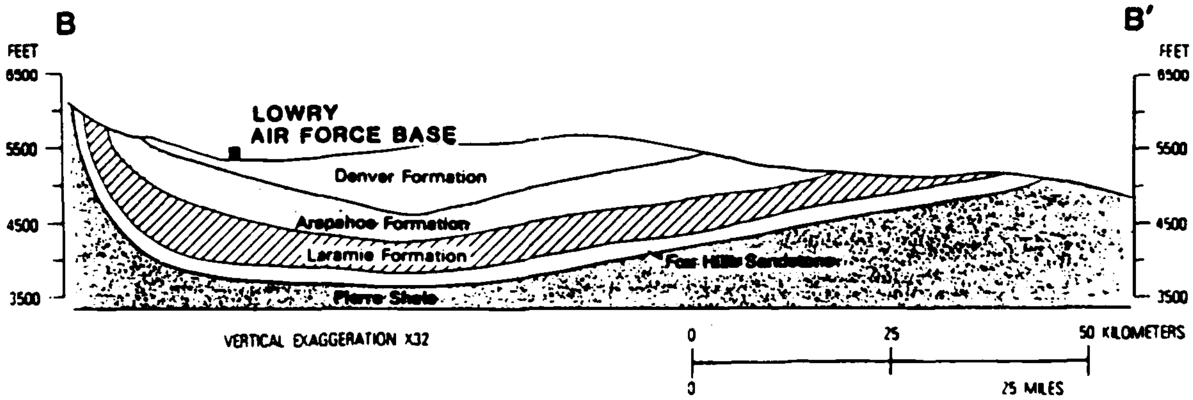


PLATE 6B GEOLOGIC CROSS-SECTION THROUGH DENVER BASIN

RELATION BETWEEN GEOLOGIC STRUCTURE AND STRATIGRAPHY LOWRY AFB

SOURCE: ES ENGINEERING-SCIENCE, 1983.

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TABLE 2

SUMMARY OF GROUND WATER RESOURCES
DENVER BASIN, COLORADO

SYSTEM	FORMATION	THICKNESS (feet)	PHYSICAL CHARACTER	WATER SUPPLY
Quaternary	Loess and alluvium	7 - 80	Unconsolidated sand, silt, and clay	Locally may yield small to moderate amounts of water to wells
Tertiary	Dawson Arkose Denver Formation Arapahoe Formation	1000 - 1200	Sand, clay, shale, and sandstone with some coal seams	Yields small to moderate amounts of water to wells
Upper Cretaceous	Laramie Formation	600 - 650	Sand, clay, and shale; coal seams are common	Yields small to moderate amounts of water to wells; quality varies locally
	Fox Hills Sandstone	200	Shale, shaley sandstone, and sandstone	Important source of water
	Pierre Shale	5000 - 8000	Shale	
Middle Cretaceous Age Rocks and Older	Not studied			

Source: Adapted from Engineering-Science, 1983.

Throughout the basin, ground water occurs under either water table or artesian conditions. In general, water table conditions exist in the outcrop areas and artesian conditions exist elsewhere. In all the upper aquifers, the quality of the ground water is generally less than 500 mg/L of total dissolved solids. Locally elevated levels of iron, sulfate, and hardness may be found in all the aquifers. Ground water flow is generally to the north, although flow in individual aquifers may vary. For example, ground water in the Denver Formation generally flows from the higher central part of the aquifer out towards the margins, while flow in the underlying Arapahoe and Laramie-Fox Hills aquifers is generally from the west and east towards the center of the basin, then northward.

The Denver Basin is seismically active, and the area near Lowry AFB has been the center of earthquakes ranging from II to VII on the Modified Mercalli Intensity Scale since 1962.

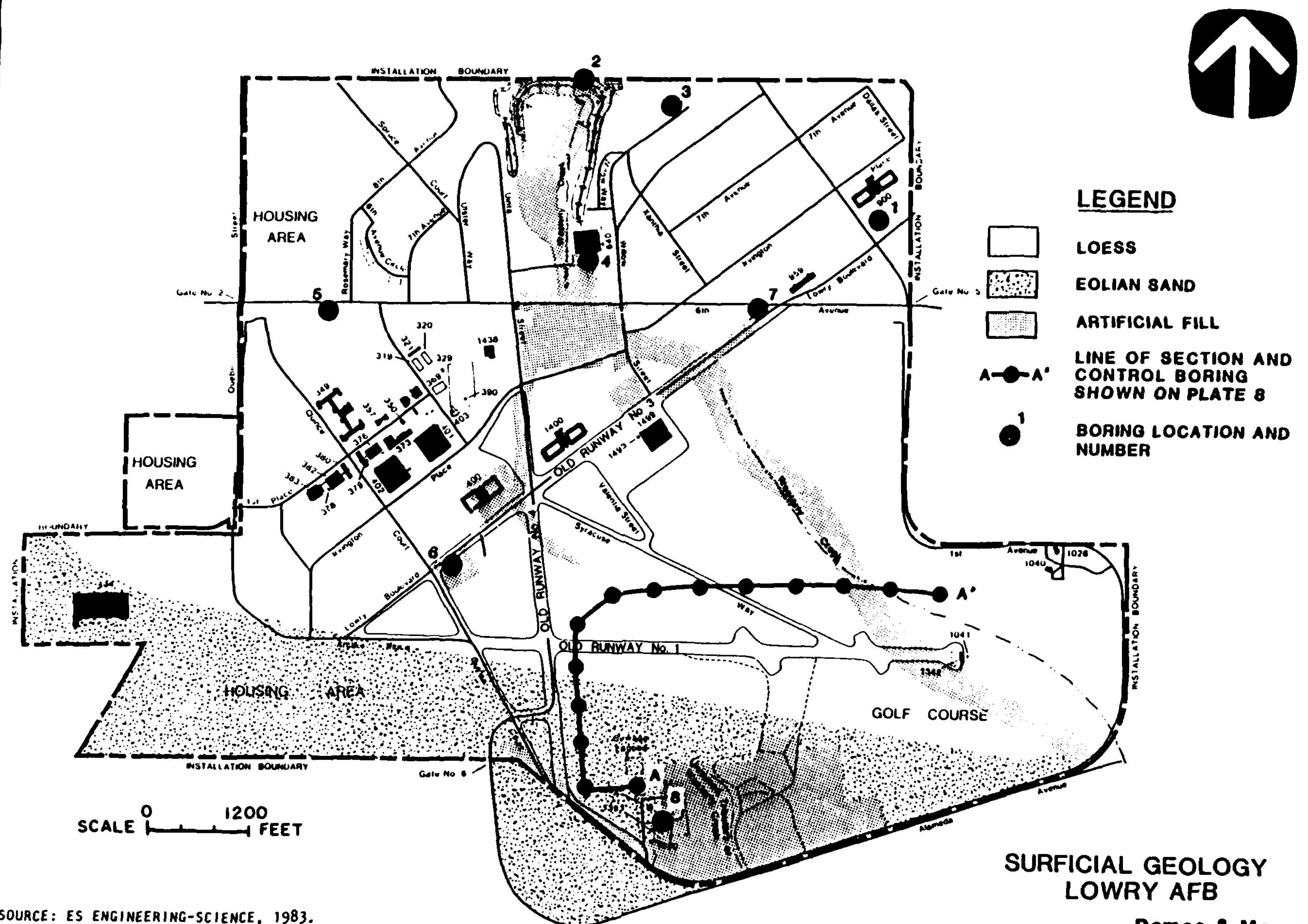
In the Denver Basin, ground water recharge results from several sources. In the deeper parts of the basin, it occurs primarily from downward percolation of water from overlying aquifers. Along the margins of the basin, recharge occurs primarily from streams and rivers flowing over the outcrops of the aquifers. In those parts of the basin where large parts of the aquifer are exposed at the surface, recharge will also occur from precipitation falling on the surface of the aquifer.

C. GENERAL BASE HYDROGEOLOGY

Two of the above aquifers are found beneath Lowry AFB: the Denver Formation and unconsolidated alluvial and eolian deposits. The eolian deposits are primarily sand and loess of Quaternary age with some alluvium and artificial fill. These deposits generally are thin (7 to 80 feet thick) and relatively permeable. Plate 7 depicts the areal distribution of the surficial materials. Plate 8 presents a cross section through these deposits.

Ground water in the unconsolidated deposits is found at shallow depths beneath Lowry AFB. Engineering-Science reported that in 1977 the depth to water varied from approximately 5 to 15 feet. During this investigation, the depth to water ranged from 3 to 20 feet below the ground surface.

Flow of water in both the Denver Formation and the unconsolidated deposits is generally to the north-northwest.

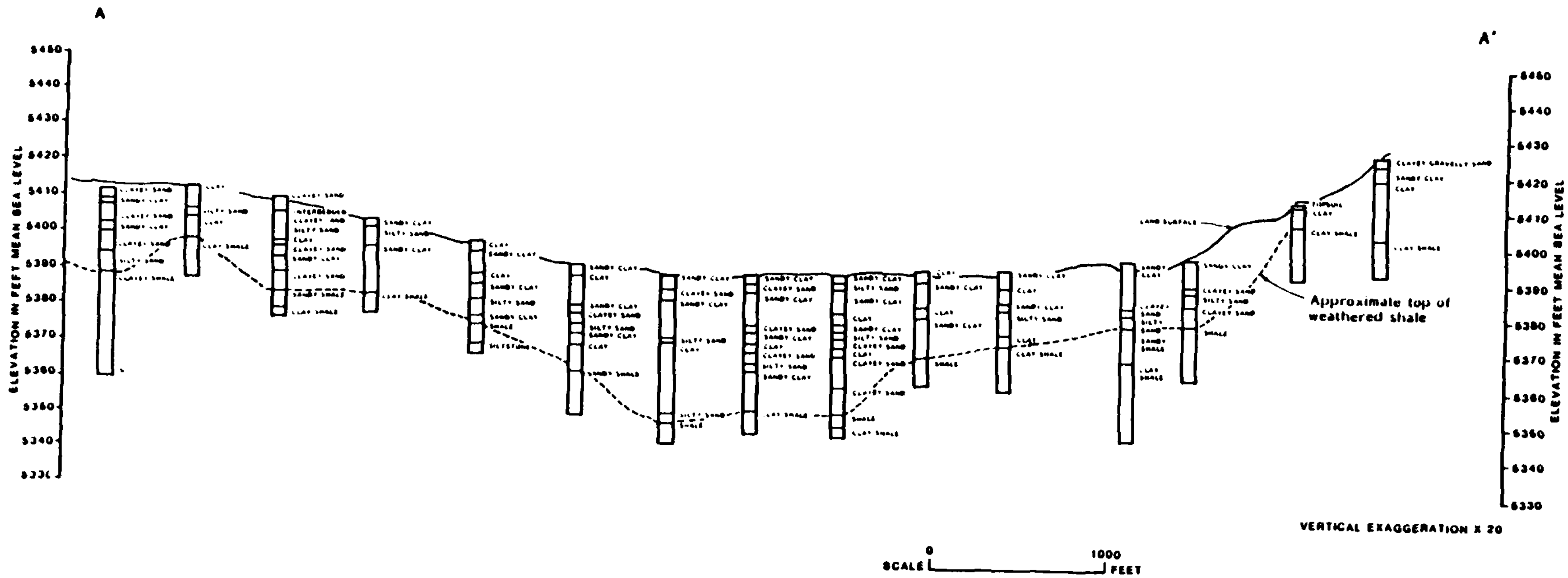


SOURCE: ES ENGINEERING-SCIENCE, 1983.

SURFICIAL GEOLOGY
LOWRY AFB

Dames & Moore

PLATE 7



SOURCE: ES ENGINEERING-SCIENCE, 1983.

GEOLOGIC CROSS-SECTION THROUGH UNCONSOLIDATED DEPOSITS LOWRY AFB

Dames & Moore

PLATE 8

Historically speaking, ground water quality in the vicinity of Lowry AFB is good, although iron and total dissolved solids (TDS) are slightly high. Table 3 lists chemical analyses from wells at the base or its annexes. The geographical relationship of the various sampling locations to Lowry AFB is shown in Plate 1. It should be pointed out that with the exception of the two deep wells located on Lowry AFB at Buildings 950 and 1432, all other Air Force wells are located great distances from Lowry AFB proper. For example, the Dillon Recreation Area is located in the mountains approximately 80 miles west of Lowry AFB. The two deep wells on the base, noted above, are no longer in use. Use of the wells ceased in 1976 due to quality of the water and high water temperature. The wells are now capped and welded shut (Sgt. Carrol, personal communication, 1986).

Engineering-Science (1983) noted that surface water quality at the base varies areally. In 1982, the portion of Westerly Creek and the storm drainage system that drains the southeast portion of the base had TDS levels of 1100 to 1500 mg/L. The drainage system for the south and southwest parts of the base had TDS levels of 200 to 600 mg/L. The high TDS is, in part, attributable to high sulfate concentrations, approximately one-half of the dissolved solids content. The source of the sulfate is unknown, but it could be occurring from off-base sources (Engineering-Science, 1983). It is possible that the sulfate is leaching out of the underlying Denver Formation. Robson and Romero (1981) reported that the Denver Formation locally contains high concentrations of sulfate. The high TDS levels may also be due, in part, to the fact that Westerly Creek drains a large urbanized area southeast of Lowry AFB. Westerly Creek is classified for recreational use by the Colorado Department of Health. Kelly Road Dam, which is located on the creek at the north end of the base, provides flood protection to residences downstream.

Plate 9, from the Engineering-Science (1983) report, shows the approximate limits of flooding for the U.S. Army Corps of Engineers Standard Project Flood (SPF). The recurrence interval for the SPF lies between once every 100 years and once every 500 years (Engineering-Science, 1983). Areas 1, 2, and 3 are located outside the limit of the SPF and will not be affected should any flooding occur. Area 4, Auto Hobby Shop (Site S-5) lies at the border of the SPF. If the surface soils that were contaminated by oil and grease (see Section IV.B.4) are removed, the probability of contaminant migration from the soils at this site should be significantly reduced.

TABLE 3

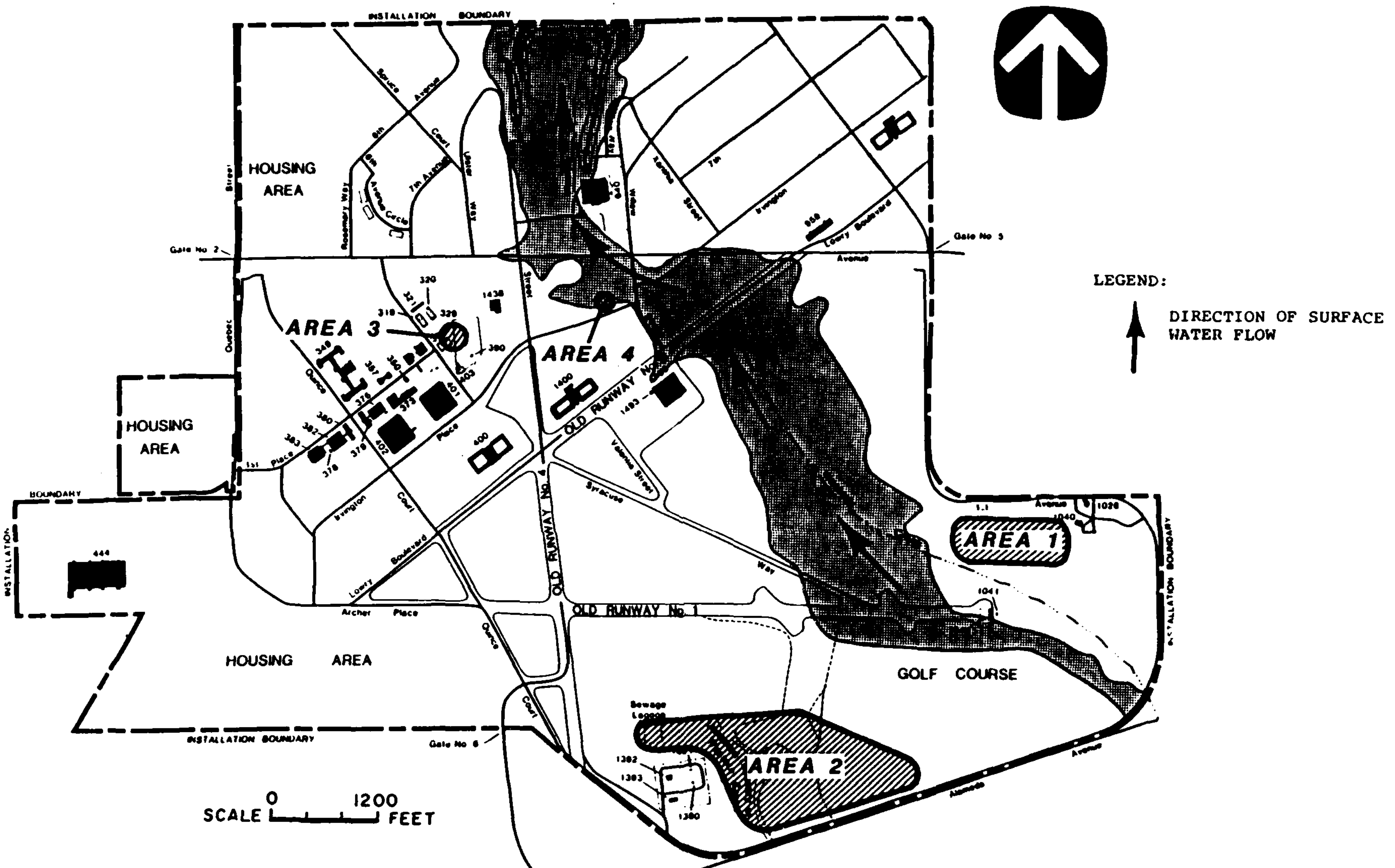
SUMMARY OF SELECTED CHEMICAL ANALYSES FOR WATER FROM WELLS
LOWRY AIR FORCE BASE, COLORADO

WELL LOCATION	WELL DEPTH (ft)	WATER SAMPLING DATE	PARAMETER AND RECOMMENDED LIMIT[a] (mg/L)											
			Ca (NA)	Mg (NA)	Na (NA)	K (NA)	HCO_3 (NA)	CO_3 (NA)	SO_4 (250)	Cl (250)	Si (NA)	Fe (0.3)	TDS (500)	pH (NA)
Building 950[b]	2023	11/16/71	3.0	0.4	220.	2.2	521	0	0.	58.	15.	0.36	588	7.8
Building 1432[b]	2000	11/16/71	3.2	0.6	230.	2.1	518	0	0.0	57.	15.	0.48	592	7.9
Training Annex, Demonstration Range	1384	11/16/71	7.3	0.8	70.	6.7	200	0	15.	3.7	14.	0.20	234	8.2
		07/27/72	7.9	0.6	71.	13.	152	23	21.	3.9	12.	0.19	250	8.6
		07/16/73	10.	0.9	110.	4.8	185	17	18.	55.	12.	0.25	309	8.9
		06/13/74	9.0	0.9	71.	3.3	185	1	20.	7.2	13.	0.15	215	8.5
		12/01/75	11.	0.6	71.	4.7	173	7	21.	7.4	11.	0.15	210	9.0
		07/29/76	13.	1.2	71.	7.0	184	0	30.	9.4	11.	0.11	240	--
Training Annex, Ammunition Storage Area	1500	11/22/71	12.	1.7	79.	6.3	157	0	87.	7.4	11.	0.38	268	8.5
		07/27/72	14.	3.4	100.	8.3	132	0	150.	11.	9.6	3.2	392	8.2
		07/16/73	37.	4.5	92.	7.9	154	3	180.	12.	10.	0.24	418	8.4
		06/13/74	23.	2.8	79.	4.2	161	1	86.	8.9	11.	0.04	313	8.5
		12/01/75	13.	1.3	69.	4.2	147	6	50.	4.9	8.8	0.17	226	8.6
		07/29/76	15.	2.0	76.	4.7	149	0	75.	6.9	9.2	0.24	264	--
Training Annex, Stock Well No. 1	11	10/11/74	--	--	--	--	--	--	--	21.	--	--	667	--
Training Annex, Stock Well No. 2	24	10/11/74	--	--	--	--	--	--	--	26.	--	--	905	--
Dillon Recreation Area	108	07/26/72	7.9	0.9	1.3	0.8	43	0	4.7	2.1	6.9	2.9	66	6.2
		07/11/73	6.7	0.9	3.9	1.3	41	0	3.8	3.3	6.7	5.9	49	7.0
		06/12/74	5.5	0.9	2.1	1.0	30	0	4.4	2.0	7.2	3.8	66	6.7
		07/28/76	7.3	1.2	2.1	0.8	44	0	5.2	2.6	6.3	6.1	56	--

[a]Number in parentheses is the recommended limit for public water supply, in mg/L (USEPA, 1975).

[b]No longer being used.

Source: Engineering-Science, 1983.



AREA INNUDATED BY
THE STANDARD PROJECT FLOOD
LOWRY AFB

SOURCE: ES ENGINEERING-SCIENCE, 1983.

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PLATE 9

D. GENERAL GROUND WATER POLLUTION

Because the water table is close to the surface at Lowry AFB and the soils are permeable, there exists a potential for ground water contamination to occur in areas where hazardous wastes are disposed of improperly. According to estimates by Engineering-Science (1983), lateral movement of contaminants in the subsurface would follow the general ground water flow direction (north-northwest) at an average velocity of less than 135 feet per year. Although this is a slow rate of movement, the primary limiting factors affecting contaminant migration in the ground water are the attenuating capabilities of the soils and the lithologies of the Denver Formation.

To have accurately determined the complete extent of ground water contamination emanating from Lowry AFB was beyond the scope of this investigation, as it would have required the drilling of numerous test wells and/or sampling of surrounding water wells. However, based on professional knowledge and experience, it is possible to make educated assumptions regarding the extent of, or potential for, the pollution of off-base water supplies.

Pollution of ground water supplies results from a number of factors. Some of these are permeability of underlying bedrock, source and location of pollution, amount and kind of contaminated liquids that have entered the aquifer, aquifer material, aquifer permeability, direction and rate of ground water flow, depth to water below the land surface, and aquifer attenuation capability.

Contaminated fluids (commonly called "leachates") escaping from a landfill or other similar facility will migrate both vertically and horizontally downward until they encounter the ground water and/or an impermeable bedrock surface. If the subsurface conditions are favorable, the leachate then will flow downgradient either at the top of the impermeable bedrock or with the ground water. The following hypothetical example is used to describe a general situation; this description may not be entirely representative of the conditions at Lowry AFB and is provided as an aid in visualizing plume movement.

Plates 10A and 10B from Freeze and Cherry (1979) depict the generalized movement of leachates in the subsurface environment. Plate 10A, a cross sectional view through an aquifer, shows how pollution concentration levels decrease both vertically and horizontally in the downgradient direction. Plate 10B, a plan view, shows the dispersion of a continuously introduced tracer in a uniform flow field. The tracer is a generalized model of the lateral distribution pattern a contaminant plume would follow. The important point that both illustrations make is that the contaminated plume is not very wide and extends downgradient. A fact not shown by the illustrations is the natural cleansing mechanism of the aquifer. Depending upon the chemical nature of the contaminants and the aquifer material, it is possible that the contaminants will be removed as the fluid moves through the aquifer.

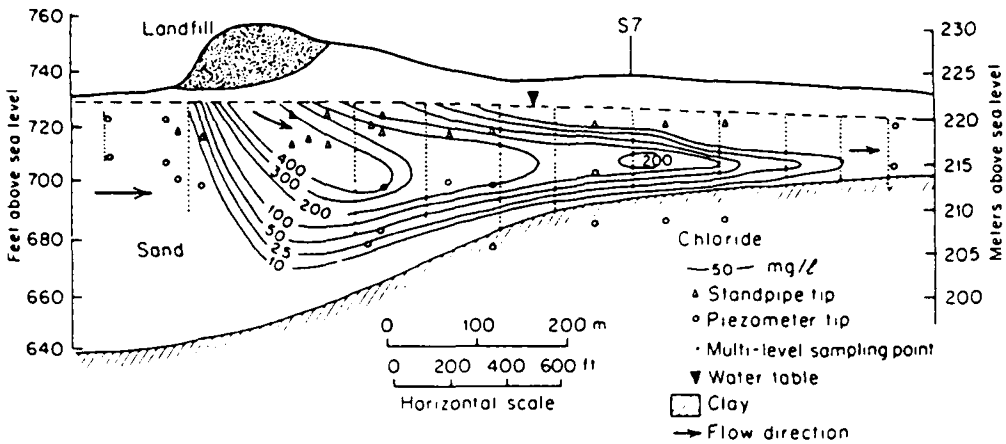

PLATE 10A PLUME OF LEACHATE MIGRATING FROM A SANITARY LANDFILL ON A SANDY AQUIFER; CONTAINED ZONE IF CONTAINED ZONE IS REPRESENTED BY CONTOURS OF CI- CONCENTRATION IN GROUNDWATER.

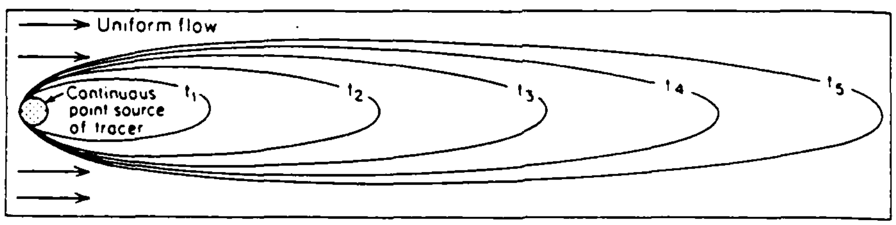

PLATE 10B SPREADING PLUME IN A TWO-DIMENSIONAL UNIFORM FLOW FIELD IN AN ISOTROPIC SAND. CONTINUOUS PLUME WITH STEP-FUNCTION INITIAL CONDITION.

SOURCE:

MODIFIED FROM FREEZE AND CHERRY, 1979; THIS IS A HYPOTHETICAL EXAMPLE AND MAY NOT REPRESENT THE CONDITIONS AT LOWRY AFB.

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The above description describes movement of leachates in a shallow unconsolidated aquifer. The same hypothetical principles apply to a deep consolidated bedrock aquifer if there is an avenue, such as a fracture or a fault, along which the leachates may move to depth. However, the chances of locating such fractures in the Denver Formation would be very slim, quite costly, and very difficult. Once the leachates have entered the porous and permeable zones of the bedrock formation, they will continue to move downgradient.

As noted earlier, two aquifers are found at Lowry AFB: unconsolidated surficial alluvial and eolian deposits and the Denver Formation. Of the two, the one having the greater potential for pollution is the surficial porous unconsolidated sand and gravel deposits. All the sites investigated were either located on or constructed in these deposits. Depending upon the time of year and climatic conditions, it is possible for the elevation of the ground water table to vary from the surface to the base of the aquifer. Without a detailed investigation having been conducted, it is not possible to accurately map the direction of ground water flow in these deposits in the Lowry AFB area. However, generally speaking, the water will flow in the same direction as the overlying land surface slopes, towards Westerly Creek and then north-northeast.

The possibility is small that water in the Denver aquifer could become polluted from activities at Lowry AFB. The Denver Formation consists of interbedded layers of clay, silts, and sandstones, material difficult for downward percolating fluids to move through. It is possible that downward migrating leachates could migrate to depth along fractures and faults; however, if they are present, they have not been mapped. Ground water in the Denver aquifer in the vicinity of Lowry AFB occurs at a depth of approximately 140 feet and flows to the north (Robson, 1984). To our knowledge, no reports have been received by state regulatory or health officials regarding contaminated Denver aquifer water wells in the Lowry AFB area.

In summary, due to the following facts it is our belief that the risk for pollution of water wells downgradient from Lowry AFB is small:

1. Emplacement of hazardous waste at the various sites on Lowry AFB ceased several years ago;

2. There are no wells immediately adjacent to any of the sites;

3. There are no wells immediately adjacent to the north boundary of the base;

4. Aquifer recharge since emplacement ceased has tended to dilute any polluted ground water;

5. Natural aquifer recharge is increased by the practice of lawn irrigation in the urban area downgradient of Lowry AFB; and

6. Evapotranspiration downgradient of the hazardous waste sites will decrease flow times.

Based on the above, it is reasonable to assume that only those wells located immediately downgradient from any of the four areas or immediately along Westerly Creek north of the base that draw water from the unconsolidated deposits could be impacted by contaminated ground water from Lowry AFB.

It should also be pointed out that there is a wide variety of commercial developments along Colfax Avenue, the major east-west thoroughfare located approximately ½ mile north of the base. These developments include gasoline stations that may contain underground storage tanks. The material handling and disposal practices of these developments would have to be assessed to determine any possible impact they may have on local ground water quality. Only in this manner could the contribution of Lowry AFB to local ground water problems be differentiated from other local sources.

E. AREA-SPECIFIC GEOLOGY AND HYDROGEOLOGY

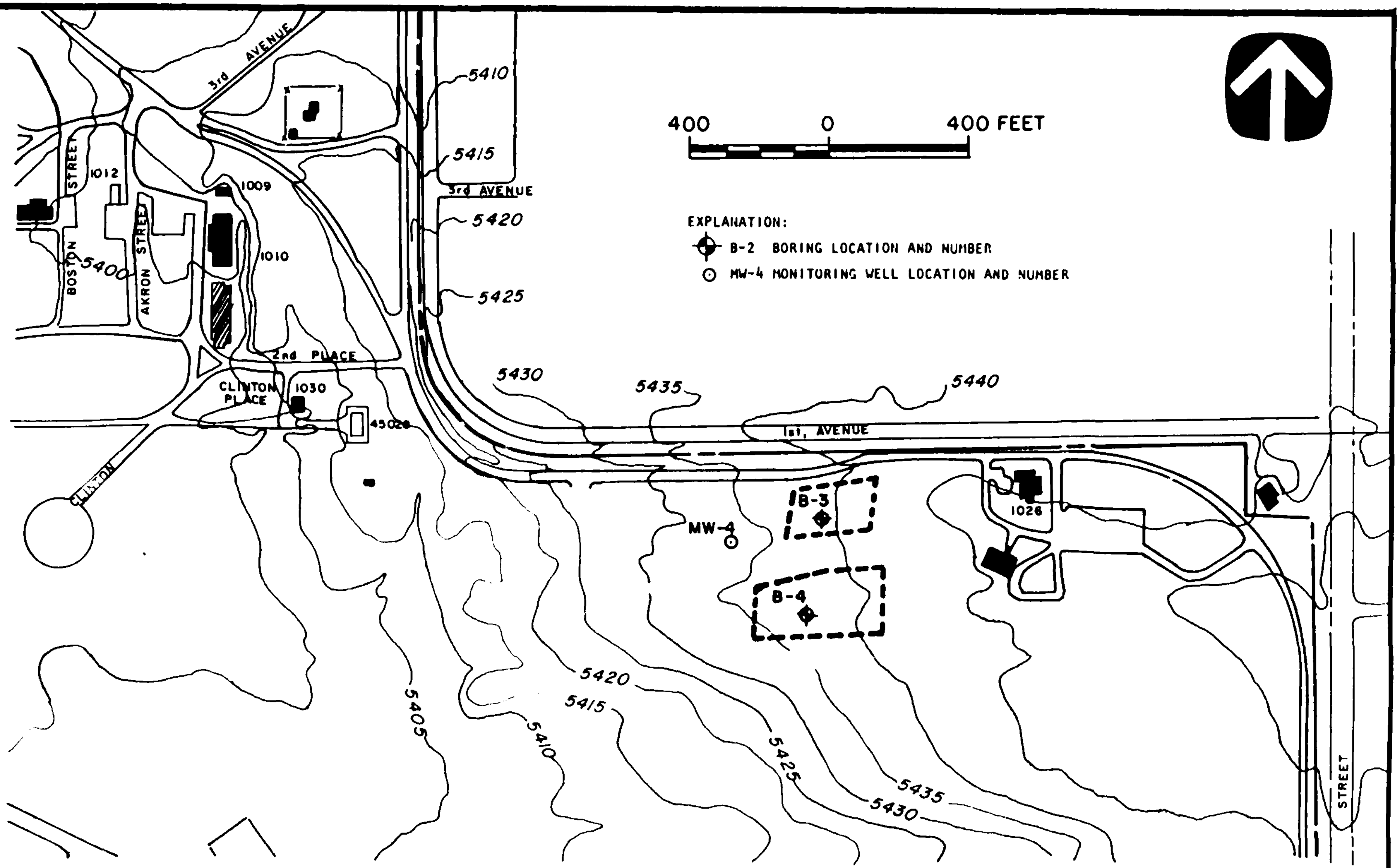
This section presents the results of the surface and subsurface investigations conducted during Phase II, Stage 1 at the four areas at Lowry AFB. The field program is described in Section III, and the results of the chemical analyses are presented in Section IV. Boring logs are presented in Appendix C.

1. Area 1, Fire Training Zone: Sites FT-1 and FT-2

Site FT-1, the fire training area from 1946 to 1965, is located within the boundaries of what is now the base golf course, near the eastern edge of the base (Plate 11). One boring, B-4, was placed within the fire training area, and a monitoring well, MW-4, was placed in an area downgradient of the site.

Site FT-2, the fire training area from 1965 to 1980, is just north of FT-1, between the golf course and East First Avenue (Plate 11). One boring, B-3, was placed within the area of this fire training pit.

The subsurface profile at B-3, B-4 and MW-4 consists of clayey or sandy clay soils with interbedded lenses of gypsum crystals and some sand layers. Black sticky sand was found in B-3 at about 9 feet and what appears to be charred debris in MW-4 at approximately 16 feet. Ground water was encountered at 16 feet in B-3 and at approximately 37 feet in MW-4 during drilling and 39 feet during installation. The static water level is at approximately 18 feet in MW-4.



SOURCE: U.S. AIR FORCE DETAILED UTILITY PLANS MAP, LOWRY AFB, COLORADO, 1982

CONTOUR INTERVAL: 5 FEET

AREA 1 SITES FT-1 AND FT-2
LOWRY AFB

Dames & Moore

PLATE II

Moisture content in analyzed soil samples ranged from 16 percent in B-3 to 22 percent in B-4 at 2.5 feet. HNU photoionization meter readings were at background levels during drilling of B-3 and MW-4 but were 150 ppm in B-4 at 6.5 and 7.5 feet.

2. <u>Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1</u>

Three monitoring wells (MW-1, MW-2, and MW-3) were located in the areas downgradient of the three components of the sanitary landfill zone: the two landfills, D-1 and D-2, and the sewage lagoon, T-1 (Plate 12). MW-1 is adjacent to the north side of the fence around the sewage lagoon. MW-3 is north-northwest of the center of a depression over the inactive landfill, D-2. MW-2 is north of the center of the active landfill area, D-1.

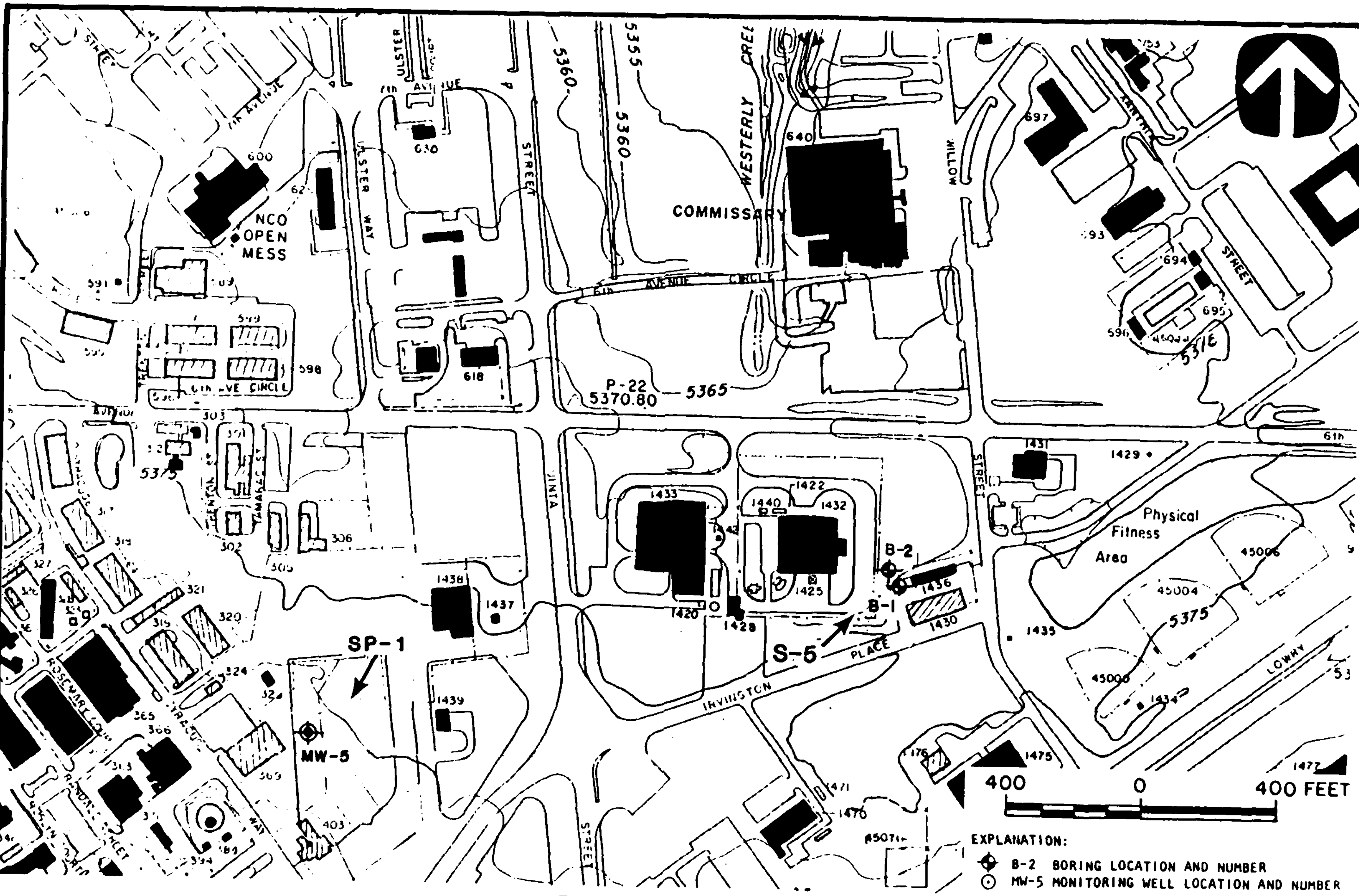
A review of the Phase I report indicated that the direction of ground water movement in the southern portion of the base is to the north-northwest. This is a slightly more northerly direction than described in the Presurvey report. The monitor wells in Area 2 were positioned during the mobilization phase of field work to maximize the possibility of intercepting plumes from the individual sites.

The subsurface profile at these sites consists of approximately 30 feet of sand, sandy clay and clayey sand over weathered claystone in MW-1 and MW-2 and sandstone in MW-3. Ground water was not encountered in MW-1 during drilling. During well installation, ground water was at a depth of 6 feet in MW-1 and MW-2 and at a depth of 12 feet in MW-3. Static water levels, measured in early November 1984, were at 3.1 feet in MW-1, 3.2 feet in MW-2, and 10.4 feet in MW-3. Moisture content in analyzed soil samples ranged from 12 percent at 2.5 feet to 30 percent at 30 feet in MW-1. HNU photoionization meter readings were at background levels throughout drilling at these sites.

3. <u>Area 3, Old Jet Fuel Yard Area: Site SP-1</u>

Site SP-1 is the location of numerous small spills of jet fuel during the 1950s and early 1960s. One monitoring well, MW-5, was placed in the parking lot of the old fuel yard (Plate 13).

During the pre-drilling field inspection and discussions with base personnel, it was learned that the monitor well at Site SP-1 should be located southeast of Building 329 rather than northwest as indicated in our Presurvey report and the Statement of Work. A review of files indicated that a map interpretation error was made during the Presurvey, as the location of Building 329 was misinterpreted. Therefore, the well was located southeast of Building 329 to intercept any contaminant moving downgradient from SP-1.



SOURCE: U.S. AIR FORCE DETAILED UTILITY PLANS MAP, LOWRY AFB, COLORADO, 1962

CONTOUR INTERVAL: 5 FEET

AREA 3 SITE SP-1 AND
AREA 4 SITE S-5
LOWRY AFB

Dames & Moore

PLATE 13

The subsurface profile in MW-5 consists of interbedded sand and clay with some gravel. Bedrock was encountered in this 40-foot deep boring. Moisture content of analyzed soil samples ranged from 1 percent at 20 feet to 13 percent at 5 feet. Ground water was encountered at a depth of 20 feet. HNU photoionization readings were at background levels, although an occasional fuel odor was noted during drilling at 30 feet.

4. Area 4, Auto Hobby Shop: Site S-5

Two borings, B-1 and B-2, were placed near an underground waste oil storage tank at Site S-5 (Plate 13).

The subsurface profile at Site S-5 consists of sandy silt over sandy clay over sand (B-1) or silty sand (B-2). B-1 was 14 feet deep; ground water was encountered at 12 feet. B-2 was 11.5 feet deep; ground water was encountered at 8 feet. Analyzed soil samples ranged from 4 percent moisture at the surface to 16 percent at 20 feet in B-2. HNU photoionization meter readings were at background levels during drilling.

F. HISTORIC GROUND WATER PROBLEMS

Robson and Romero (1981) presented an in-depth description of the hydrogeological conditions of the Denver aquifer. Their investigation showed ground water in the vicinity of Lowry AFB provides water for domestic, municipal, industrial, and commercial uses. Up to 50 feet of decline in the water table has been reported for the area around Lowry AFB during 1958 through 1978. This water level decline is due to increased pumpage in developing suburban areas and to the spread of the decline of water levels from the metropolitan area.

Ground water quality in the Denver aquifer is generally good, but naturally occurring high concentrations of TDS, sulfate, and iron are scattered problems. In general, the quality of the ground water found in the Denver Formation improves away from the margins of the formation. Robson and Romero (1981) reported that in the vicinity of Lowry AFB, ground water in the Denver Formation is either a sodium bicarbonate or sodium sulfate type, contains 25 mg/L of dissolved sulfate and 200 mg/L of total dissolved solids, and is classified as being soft.

G. LOCATIONS OF WELLS ON AND OFF BASE

The Denver Water Board now provides 100 percent of the water supply for Lowry AFB. From approximately 1955 to 1976, the two deep wells on the base were used for irrigation. One well is located in the northeast corner of the base, at the intersection of Dallas Street and Irvington Place; the second well is at the center of the base, near the intersection of Irvington Place and Willow Street. Both wells drew from the Laramie-Fox Hills aquifer. As noted earlier, these wells are no longer used.

Table 4 is a list of all registered water wells within 2 miles of Lowry AFB. It should be pointed out that although these wells are registered with the State of Colorado, there is no guarantee that they are still in existence and/or still in use. While the owner of a registered well is requested to report any change in use to the state, in most instances they do not. In addition, no provision is made by the state to keep its records up to date. It should also be pointed out that all information on the application form is data reported by the well owner and is not verified by state officials. Therefore, in many instances, much of the reported information, especially the location, is incorrect. In plotting the locations of wells shown in Plate 14, it was determined that 20 percent of these wells were mislocated.

Without a house-to-house canvass, it is impossible to state how many of these wells are still in existence and still being used. Due to the nature of water distribution in the Denver metropolitan area and requirements imposed on the well owner, it is Dames & Moore's belief that most of these wells are used for lawn irrigation, with very few of them being used for domestic purposes. Plate 14 shows the locations of the wells within a 1-mile radius of Lowry AFB.

TABLE 4

REGISTERED WATER WELLS
VICINITY OF LOWRY AIR FORCE BASE, COLORADO

TOWNSHIP	RANGE	SECTION	ADDRESS	USE[a]	YIELD (gpm)	DEPTH (ft)	DIRECTION	REMARKS[b]
3S	67W	32 NW SE	1950 Magnolia	1	10	80	NE	
3S	67W	32 NW SE	1600 Monaco Pkwy.	6	20	60	N	
3S	67W	34 NE SW	10115 E. 23rd	1	3	15	N	1
3S	67W	34 NE SW	1733 Dallas	1	6	80	ENE	
3S	67W	34 NE SW	1770 Dayton	1	1	50	E-N	
3S	67W	34 NW SW	1740 Alton St.	1	8	15	ENE	
3S	67W	34 SE SW	1604 Clayton	1	8	40	ENE	
3S	67W	34 SW SW	1625 Akron	1	8	20	ENE	
3S	67W	34 SW SW	1665 Akron	1	20	21	NE	
3S	67W	34 NW SE	1775 Delmar	1	4	20	NE	
3S	67W	34 NW SE	1788 Elmira	1	10	22	NE	
3S	67W	34 SE SE	1647 Havana	1	7	64	NE	
3S	67W	35 NE NE	2332 Oswego	1	15	58	NE	1
3S	67W	35 NE NE	?	1	20	40	NE	1
3S	67W	35 NE NE	2332 Oswego	1	15	58	NE	1
3S	67W	35 NE NE	?	1	20	40	NE	1
3S	67W	35 NW NE	2301 Newark	1	15	50	NE	1
3S	67W	35 NW NE	2301 Newark	1	15	50	NE	1
3S	67W	35 SE NE	1805 Peoria	1	40	1100	E	2
3S	67W	35 SE NE	2201 Oswego	1	10	44	NE	1
3S	67W	35 SE NE	2241 Oakland	1	16	49	NE	1
3S	67W	35 SE NE	2065 Nome	1	3	?	NE	
3S	67W	35 SE NE	2241 Oakland	1	16	49	NE	1
3S	67W	35 NE SW	1957 Lansing	1	10	50	NE	
3S	67W	35 SW SW	1633 Jamaica	1	?	80	NE	
3S	67W	35 SE SW	1717 Oakland	1	?	?	NE	
3S	67W	35 SE SE	1612 Paris	6	?	20	NE	
4S	67W	02 SW NW	1389 Kenton	1	14	66	NE	
4S	67W	02 SW NW	1141 Joliet	1	3	27	E	
4S	67W	02 NW SW	1000 Hanover St.	1	240	150	E	2

[a]Use Code:
1 = Domestic including lawn watering
2 = Livestock
3 = Domestic and livestock
4 = Commercial
5 = Industrial
6 = Irrigation (large capacity wells)
7 = Irrigation and stock
8 = Municipal
9 = Others
0 = In-house use

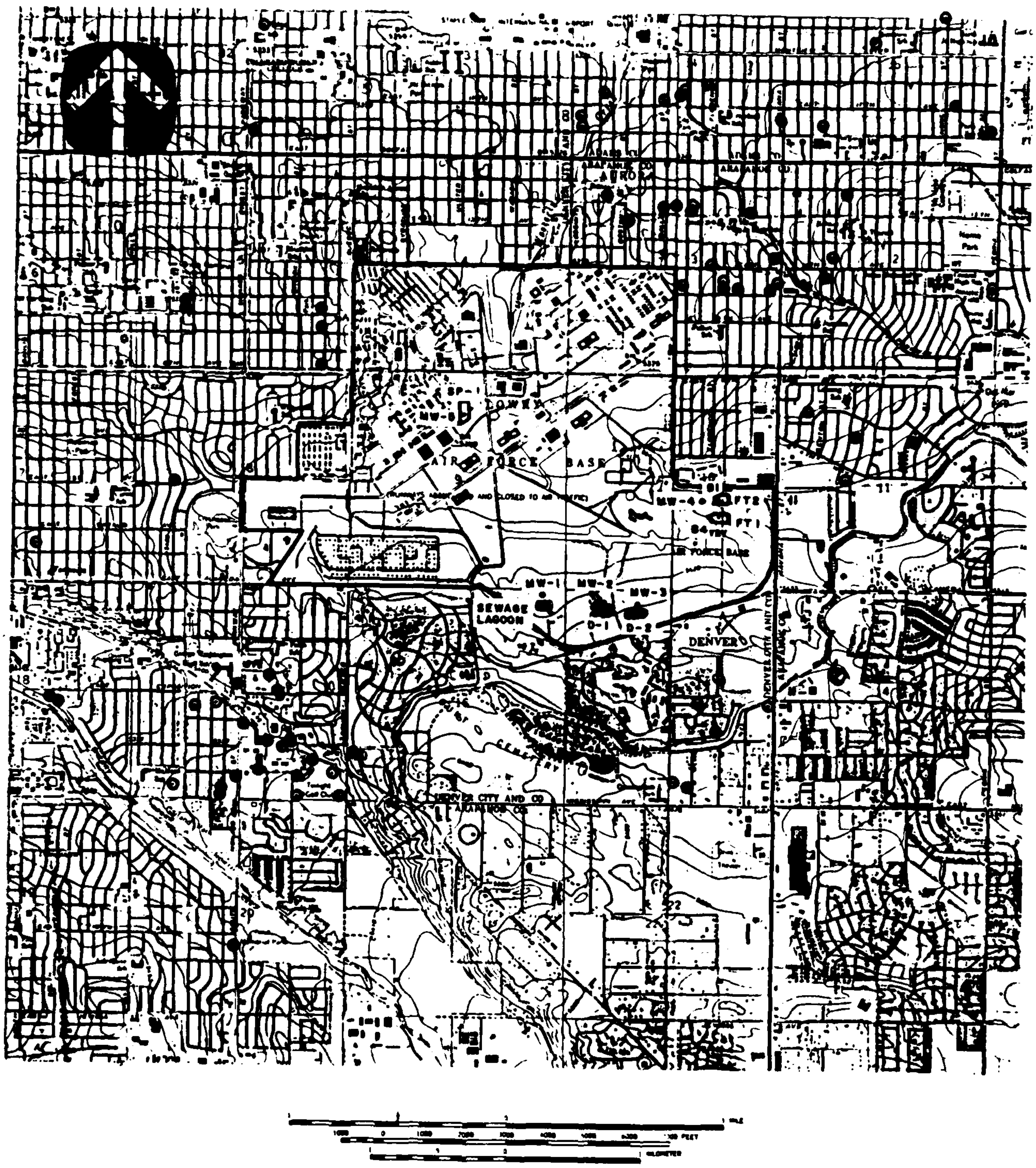
[b]Remarks:
1 = Location off map and not plotted.
2 = Doubtful location.

TABLE 4 (continued)

TOWNSHIP	RANGE	SECTION	ADDRESS	USE[a]	YIELD (gpm)	DEPTH (ft)	DIRECTION	REMARKS[b]
4S	67W	02 NW SW	1092 Jamaica	1	3	25	E	
4S	67W	03 NE NE	1301 Geneva	1	5	17	E	
4S	67W	03 NW NE	1356 Emporia	1	15	60	NE	
4S	67W	03 NW NE	1320 Emporia	1	20	24	NE	
4S	67W	03 SE NE	1085 Peoria	1	35	1050	E	
4S	67W	03 SE NE	1120 Hanover	1	4	19	E	
4S	67W	03 NE NW	1325 Dayton	1	3	25	N	
4S	67W	03 NW NW	1353 Beeler	1	12	15	N	
4S	67W	03 SE NW	480 Florence	4	3	50	E	2
4S	67W	03 SE NW	1315 Dallas	1	10	50	N	
4S	67W	03 SE NW	1216 Boston	1	10	40	N	
4S	67W	03 NE SE	835 Pontiac	1	12	35	W	2
4S	67W	03 NE SE	1049 S. Havana	1	10	31	E	2
4S	67W	03 NE SE	1025 Galena	1	6	81	E	
4S	67W	03 NE SE	925 Fulton	1	1	75	E	
4S	67W	03 NW SE	941 S. Fulton	1	30	63	E	2
4S	67W	03 NW SE	1065 Emporia	1	12	60	E	
4S	67W	03 NW SE	1101 Florence	1	6	50	E	
4S	67W	04 SE NW	4875 Parker	1	10	100	SE	2
4S	67W	05 NE SW	?	1	5	100	?	
4S	67W	05 NW SW	860 Krameria	1	30	45	W	
4S	67W	05 SE SW	892 S. Krameria	1	10	35	W	2
4S	67W	07 NE SW	5 Cherry	1	3	29	W	1
4S	67W	07 SW SE	175 S. Eudora	1	15	30	W	
4S	67W	08 NW SW	100 Jersey	1	7	126	W	
4S	67W	10 NE NE	Conoco	5	18	1007	E	2
4S	67W	11 NE NW	444 Moline	1	?	60	E	
4S	67W	11 NW NW	538 Ironton Ct.	1	?	80	E	
4S	67W	11 NE SW	375 Moline	1	?	100	E	
4S	67W	15 NW NE	?	4	20	41	?	
4S	67W	15 NE SE	10450 E. Exposition	1	20	40	S	
4S	67W	15 SW SE	1000 Elmira	1	20	132	S	2
4S	67W	15 SW SE	982 S. Dayton	1	10	22	S	
4S	67W	15 SE SE	10151 E. Ford Pl.	7	15	268	S	
4S	67W	16 NE SW	730 S. Krameria	1	30	50	S	
4S	67W	16 SW SE	7877 E. Mississippi	1	?	60	S	
4S	67W	16 SW SE	7877 E. Mississippi	1	?	11	S	
4S	67W	16 SW SE	7877 E. Mississippi	1	?	10	S	
4S	67W	16 SW SE	7877 E. Mississippi	6	15	1150	S	
4S	67W	16 SW SE	939 S. Quince	1	?	25	S	
4S	67W	17 SW NE	6831 E. Center	1	20	92	SE	
4S	67W	17 SW NE	680 S. Monaco	1	13	1050	S	
4S	67W	17 NE SW	721 S. Leyden	1	25	40	SE	
4S	67W	17 NW SW	810 S. Monaco	1	15	41	S	
4S	67W	17 SW SW	1040 S. Kearney	1	10	41	S	
4S	67W	17 SE SW	1001 S. Monaco	4	30	46	S	
4S	67W	17 SE SW	7575 Parker Rd.	1	25	38	S	

TABLE 4 (continued)

TOWNSHIP	RANGE	SECTION	ADDRESS	USE[a]	YIELD (gpm)	DEPTH (ft)	DIRECTION	REMARKS[b]
4S	67W	17 SE SW	6875 Leetsdale	1	40	18	S	
4S	67W	17 SE SE	6875 Leetsdale	1	15	62	S	
4S	67W	17 SE SW	6330 Leetsdale	1	20	31	S	
4S	67W	17 SE SW	1075 S. Locust	1	30	30	S	
4S	67W	17 SE SW	1065 S. Locust	1	30	30	S	
4S	67W	17 NE SE	6767 Leetsdale	4	42	1030	S	
4S	67W	17 NW SE	6625 Parker Road	4	40	36	SE	
4S	67W	17 SW SE	6675 E. Tennessee Ave.	1	30	50	S	
4S	67W	17 SW SE	6675 E. Tennessee Ave.	6	60	44	S	
4S	67W	17 SW SE	?	6	20	33	?	
4S	67W	17 SW SE	6675 E. Tennessee Ave.	1	25	33	S	
4S	67W	17 SW SE	1160 S. Colorado Blvd.	6	150	30	SW	2
4S	67W	17 SE SE	Fairmont Cemetery	4	?	?	S	
4S	67W	17 SE SE	Fairmont Cemetery	6	300	40	S	
4S	67W	17 SE SE	Parker & Oneida	6	421	49	SE	
4S	67W	17 SE SE	1090 S. Oneida	4	100	1020	S	
4S	67W	17 SE SE	1000 S. Oneida	1	421	49	SE	
4S	67W	17 SE SE	1635 S. Monaco	4	60	46	S	2
4S	67W	18 SW NE	Glendale Water	3?	300	46	SW	
4S	67W	18 SW NE	Glendale Water	3 (8)	300	42	SW	
4S	67W	18 SW NE	950 S. Birch	3	700	45	SW	1
4S	67W	18 SW NE	999 S. Clairmont	6	700	64	SW	1
4S	67W	18 NE NW	3504 E. 12th	4	20	54	W	2
4S	67W	18 NE NW	6665 Leetsdale	1	20	1004	SW	1
4S	67W	18 NE NW	4700 E. Alameda	1	7	220	SW	1
4S	67W	18 NE NW	4600 Leetsdale	4	300	43	SW	1
4S	67W	18 NE NW	4425 Leetsdale	4	200	44	SW	1
4S	67W	18 NW NW	2120 E. Colfax	4	75	48	NW	2
4S	67W	18 NW NW	4353 E. Virginia	1	10	30	SW	1
4S	67W	18 NW NW	4353 E. Virginia	6	15	37	SW	1
4S	67W	18 NW NW	4353 E. Virginia	6	700	41	SW	1
4S	67W	18 NW NW	400 S. Colorado Blvd.	4	17	38	SW	1
4S	67W	18 SW NW	3090 Ash	4	30	52	NW	2
4S	67W	18 SE NW	3830 Adams	1	30	49	NW	2
4S	67W	18 NE SW	?	4	30	36	SW	
4S	67W	18 NE SW	?	4	32	1137	SW	
4S	67W	18 NE SW	4413 E. Kentucky	6	35	34	SW	1
4S	67W	18 NE SW	4413 E. Kentucky	4	13	57	SW	1
4S	67W	18 NE SW	?	6	396	51	SW	1
4S	67W	18 NW SW	Kentucky & Colorado	4	33	375	SW	1
4S	67W	18 NW SE	4901 E. Kentucky	6	150	34	SW	1
4S	67W	18 SW SE	1909½ W. Mississippi	4	150	39	SW	2



KEY:

⊙ REGISTERED WATER WELL

BASE MAP REFERENCE:
COMPILED FROM PORTIONS OF ENGLEWOOD, COLO., 1965, AND FITZSIMONS, COLO., 1965, U.S.G.S. 7.5 MINUTE SERIES TOPOGRAPHIC QUADRANGLES.

LOCATION OF REGISTERED WATER WELLS LOWRY AFB

Dames & Moore

PLATE 14

III. FIELD PROGRAM

A. DEVELOPMENT

The field program was developed based on Phase I of the IRP. During that phase, the sites at which hazardous materials were handled or disposed of were identified. The Phase II, Stage 1 program consisted of the following activities:

1. Drilling, soil sampling, measuring water levels, and installing and developing five new monitoring wells at three sites on the base;
2. Preparing geologic logs for each new monitoring well;
3. Collecting samples for water quality analyses from each new monitoring well;
4. Drilling, soil sampling, and geologically logging four boreholes at two sites on the base; and
5. Chemical analysis of soil and water samples.

B. IMPLEMENTATION

1. Well Installation

Five monitoring wells were constructed at three sites on Lowry AFB. The wells were constructed under the direction of Dames & Moore personnel by Custom Auger Drilling Services, Inc. of Denver, Colorado, using a truck-mounted rotary drill rig with 8-inch diameter, hollow-stem augers. Samples were collected using a 2.5-inch split spoon sampler driven by a 340-pound drop hammer. The sampler was thoroughly cleaned with a weak nitric acid solution, hexane, and distilled water before each sampling. Descriptions of the samples were made in the field by an experienced Dames & Moore technician, and these descriptions were used to prepare geologic logs for each borehole.

The boreholes were monitored for organic vapors during drilling using an HNU photoionization meter. Readings were taken at the top of the borehole during drilling and immediately before each sampling operation. The readings were recorded in a field notebook.

The casing installed for the monitoring wells was a nominal 2-inch Schedule 40 PVC pipe and well screen. The screen was 0.010-inch slot size with a 0.25-inch space between slots. All casing and screen sections were coupled with threaded joints; no PVC solvent or metal parts were used. The wells had between 25 and 35 feet of screen set so that the upper 5 feet of screen extended above the water table. Above the screen, blank casing was installed to a nominal 1 to 2 feet above the ground surface.

A gravel pack was placed in the annular space from the bottom of the well to the top of the well screen. The remainder of the annular space was filled with a cement-bentonite mixture to about 1.5 feet from the ground surface. A concrete cap was poured to the ground surface, and the installation was completed by embedding a 3-foot length of 6-inch diameter steel pipe with a locking cap approximately 1.5 feet into the concrete cap over the well pipe. The installation record for each well is provided in Appendix C.

2. Well Sampling

After drilling, each well was bailed continuously by hand with a PVC bailer until the water was clear or until five casing volumes of water had been removed. Immediately prior to sample collection, another three well volumes were removed by bailing. Temperature, specific conductance, and pH measurements of the water were made after bailing was completed. Samples were collected from the wells using a PVC sampling bailer. The bailer was suspended in the well using a polypropylene rope and was raised and lowered by hand. Prepared sampling containers, with appropriate preservatives, were filled and immediately stored in iced, insulated shipping containers. At the end of each sampling day, the water samples were shipped via air cargo to the testing laboratories (UBTL in Salt Lake City, Utah, and OEHL at Brooks AFB, Texas), where the samples were received the following day. The soil samples were stored in prepared glass containers and frozen at the end of each working day. They were shipped to the testing laboratories at the same time the water samples were shipped.

The bailer and the various probes and containers used during sampling and field testing were thoroughly rinsed after each use. All field instruments functioned well and were calibrated before and during use to ensure accuracy. Static water levels were measured during drilling operations and again during sampling.

Chain-of-custody forms were prepared and accompanied the samples from the field to the laboratory. These records documented the integrity of the samples at each point of transfer, from field personnel to shippers and couriers to the laboratory staff. The signatures of the individuals relinquishing and accepting custody of the samples and the date and time appear on the records to document transfer of samples (see Appendix F).

The two inactive base water supply wells were not sampled during this investigation.

3. Analytical Methods

The soil and ground water samples were analyzed in accordance with U.S. Environmental Protection Agency (USEPA) methods. Details of the sampling and analytical procedures are provided in Appendix E.

IV. DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

This section presents a discussion of the chemical analyses of soil and ground water samples collected during field investigations at the areas shown in Plates 11 through 13. The second portion of this section discusses the significance of the results. Area-specific geology is discussed in Section II, and the field investigations are described in Section III.

Water samples were analyzed for pH, temperature, specific conductance, cadmium, chromium, lead, nickel, silver, phenolics, TOC, TOX, oil and grease, and eight pesticides, according to the requirements specified in the Statement of Work. Table 5 summarizes the analytical results; complete analytical results as sent by UBTL are in Appendix G. Soil samples were analyzed for percent moisture, oil and grease, TOC, and TOX. Samples were subjected to acid extraction and analyzed for lead. Results are presented in Table 6.

Lead analyses were conducted on ground water samples from each of the three monitor wells at Area 2 (sanitary landfill zone) and on the ground water from MW-4 at Area 1 (fire training zone). Twelve soil samples from Area 1 and six soil samples from Area 4 (auto hobby shop) were also analyzed for lead content. Water samples from the four monitor wells were collected on November 5, 1984. Soil samples were collected in Area 1 at B-1 on October 10, 1984; at B-4 on October 15, 1984; at MW-4 on October 18, 1984; and in Area 4 on October 10, 1984.

During analysis of ground water samples for lead, severe matrix effect problems were encountered. The presence of some constituents (such as the presence of chloride and sulfates when analyzing for lead) often interferes with atomic absorption spectrophotometry analysis. These interferences, called the matrix effect, may result in less than the actual value of the contaminant being detected during analysis. Because of an unacceptably low spike recovery of 4 percent, one additional ground water sample from MW-1 was collected on September 18, 1985 and analyzed. By application of the method of standard additions, the matrix effect was confirmed and the sample was determined to have a low lead content approximately at the limit of detection. Because of the matrix effect and the consequent difficulty in interpreting results, the lead analyses for ground water have been removed from the text and appear in Appendix G, Analytical Data.

TABLE 5

ANALYTICAL REPORT
LOWRY AFB - WATER ANALYSES

PARAMETER	METHOD	UNIT	DETECTION LIMIT	PRIMARY DRINKING WATER STANDARD (µg/L)	AREA 2, SANITARY LANDFILL ZONE			AREA 1 FIRE TRAINING ZONE	AREA 3 OLD JET FUEL YARD
					T-1, MW-1	D-2, MW-3	D-1, MW-2	FT-1, MW-4	SP-1, MW-5
Oil and Grease	413.2[a]	µg/L	500.	NE	2.5	1.4	3.6	1.6	6.6
Phenolics	420.2[a]	µg/L	10.	NE	ND	0.02	0.02	--	--
Cadmium	213.1[a]	mg/L	0.01	10	ND	ND	ND	--	--
Chromium	218.1[a]	mg/L	0.05	50	ND	ND	ND	--	--
Nickel	249.1[a]	mg/L	0.05	NE	ND	ND	ND	--	--
Silver	272.1[a]	mg/L	0.01	50	ND	ND	ND	--	--
TOC	415.1[a]	µg/L	1000.	NE	11.	6.4	20.	20.	5.7
TOX	9020[b]	µg/L	10.	NE	74.	61.	93.	100.	61.
Aldrin	608[c]	µg/L	0.01	NE	ND	ND	ND	--	--
Chlordane	608[c]	µg/L	0.02	NE	ND	ND	ND	--	--
Dieldrin	608[c]	µg/L	0.01	NE	ND	ND	ND	--	--
DDD	608[c]	µg/L	0.02	NE	ND	ND	ND	--	--
DDE	608[c]	µg/L	0.02	NE	ND	ND	ND	--	--
o,p-DDT	608[c]	µg/L	0.05	NE	ND	ND	ND	--	--
p,p'-DDT	608[c]	µg/L	0.05	NE	ND	ND	ND	--	--
Endrin	608[c]	µg/L	0.02	0.2	ND	ND	ND	--	--
Endrin aldehyde	608[c]	µg/L	0.02	NE	ND	ND	ND	--	--
Heptachlor	608[c]	µg/L	0.01	NE	ND	ND	ND	--	--
Lindane	608[c]	µg/L	0.01	NE	ND	ND	ND	--	--
pH	field		NE	NE	7.3	7.2	7.2	6.9	7.2
Temperature	field	°C	NE	NE	12.0	12.0	12.0	12.0	14.0
Specific Conductance	field	µmhos/cm	NE	NE	2016.	1638.	2016.	6930.	1952.

Notes:
1. The analytical techniques between the methods published in EPA-SW-846, EPA 600/4-79-020, and Standard Methods 16th Edition are the same.
2. ND denotes value less than the limit of detection.
3. -- indicates not analyzed.
4. NE indicates no criterion established.

[a]Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, revised March 1983.

[b]Test Methods for Evaluating Solid Waste, SW-846, 2nd edition, July 1982, modified for use on O.I. Corp. Model 610 TOX analyzer.

[c]Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA 600/4-82-057, July 1982.

TABLE 6

ANALYTICAL REPORT

LOWRY AFB - SOIL ANALYSES[a]

PARAMETER	METHOD	UNIT	DETECTION LIMIT	AREA 1, FIRE TRAINING ZONE FT-2, B-3 #2 2.5-4'	FT-2, B-3 #3 5-6.5'	FT-2, B-3 #4 7.5-9'	FT-2, B-3 #6 15-16.5'	FT-1, B-4 #2 2.5-4'	FT-1, B-4 #3 5-6.5'
Lead	239.1[b]	µg/g	10.	37.	37.	33.	36.	38.	49.
% Moisture	160.3[b]	%	1.	16.	19.	17.	20.	22.	22.
Oil and Grease	413.2[b]	mg/g	0.007	ND	0.043	ND	ND	0.17	0.029
TOC	415.1[b]	µg/g	5.	2620.	2470.	6870.	240.	2300.	1900.
TOX	9020[c]	µg/g	5.	ND	ND	ND	ND	ND	ND

PARAMETER	METHOD	UNIT	DETECTION LIMIT	AREA 1, FIRE TRAINING ZONE FT-1, B-4 #4 7.5-9'	FT-1, B-4 #5 10-11.5'	MW-4 #2 2.5-4'	MW-4 #4 7.5-9'	MW-4 #6 15-16.5'	MW-4 #10 30-36.5'
Lead	239.1[b]	µg/g	10.	37.	29.	32.	37.	36.	39.
% Moisture	160.3[b]	%	1.	18.	20.	12.	25.	24.	30.
Oil and Grease	413.2[b]	mg/g	0.007	0.055	0.036	0.012	0.043	0.026	0.023
TOC	415.1[b]	µg/g	5.	354.	187.	1930.	627.	605.	357.
TOX	9020[c]	µg/g	5.	ND	ND	ND	ND	ND	ND

Notes: 1. The analytical techniques between the methods published in EPA-SW-846, EPA 600/4-79-020, and Standard Methods 16th edition are the same.

2. ND denotes value less than the limit of detection.

[a]Results have been corrected for percent moisture. Sample calculation for MW-4 #4, 7.5'-9' for TOC, reported value, 470 µg/g: 25% moisture, therefore the sample is 75% dry weight. 0.75X = 470 µg/g, X = 626 µg/g on a dry weight basis.

[b]Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, revised March 1983.

[c]Test Methods for Evaluating Solid Waste, SW-846, 2nd edition, July 1982, modified for use on O.I. Corp. Model 610 TOX analyzer.

[d]Denotes value less than the limit of detection.

TABLE 6 (continued)

PARAMETER	METHOD	UNIT	DETECTION LIMIT	AREA 3, OLD JET FUEL YARD: SITE SP-1 MW-5 #3 5-6.5'	MW-5 #5 7.5-9'	MW-5 #6 10-11.5'	MW-5 #8 20-21.5'
% Moisture	160.3^b	%	1.	13.	12.	13.	1.
Oil and Grease	413.2^b	mg/g	0.007	0.033	0.023	0.033	0.027
TOC	415.1^b	µg/g	5.	1490.	1700.	1950.	150.
TOX	9020^c	µg/g	5.	ND	ND	ND	ND

PARAMETER	METHOD	UNIT	LIMIT	AREA 4, AUTO HOBBY SHOP, SITE S-5 B-1 #1 0-1.5'	B-1 #2 1.5-3'	B-1 #5 10-11.5'	B-2 #1 0-1.5'	B-2 #2 2.5-4'	B-2 #5 10-11.5'
Lead	239.1^b	µg/g	10.	176.	40.	26.	53.	28.	38.
% Moisture	160.3^b	%	1.	9.	11.	15.	4.	6.	16.
Oil and Grease	413.2^b	mg/g	0.007	6.3	0.18	ND	0.95	0.12	ND
TOC	415.1^b	µg/g	5.	5050.	4380.	1500.	6560.	3400.	1670.
TOX	9020^c	µg/g	5.	ND	ND	ND	ND	ND	ND

A. DISCUSSION OF RESULTS

1. Area 1, Fire Training Zone: Sites FT-1 and FT-2

One monitoring well, MW-4, was installed in the area downgradient from FT-1. Concentration levels of the following were determined:

- o Oil and grease - 1.6 mg/L;
- o TOC - 20 mg/L;
- o TOX - 100 μg/L; and
- o Specific conductance - 6930 μmhos/cm.

The pH value, 6.9, was within the lower end of the recommended acceptable range of 6.5 to 8.5, as stated in the Secondary Drinking Water Regulations (40 CFR, 1979). The measured levels of TOC and TOX, along with the high specific conductance, suggest there is ground water contamination at FT-1.

Soil samples from soil boring B-4 at FT-1 had oil and grease at levels ranging from 0.029 to 0.17 mg/g dry weight (see Table 6). TOC levels, as expected, decreased with increasing depth. TOX was not detected. Lead levels ranged from 29 to 49 μg/g. Analyses of soil samples to determine background lead concentrations were not conducted. However, the concentrations measured for this site are well within the range of concentrations reported for natural soils in Colorado by other investigators (Connor and Shacklette, 1975). HNU photoionization meter readings were elevated (150 ppm) at 6 to 8 feet, and a fuel odor was noted in the soil samples from these depths. The elevated HNU readings and noticeable fuel odors suggest the soil is contaminated, at least to a depth of 8 feet, at FT-1.

At FT-2, B-3, blobs of sticky black sand were found at approximately 9 feet deep. This is very near the depth of the old ground surface, before filling for the golf course in this area. Elevated TOC at a depth of 7.5 to 9 feet and oil and grease levels below the limit of detection (Table 6) indicate the black substance is not oil and possibly could be decayed vegetation. Oil and grease was 0.043 mg/g dry weight at 5 feet; lead levels ranged from 33 to 37 μg/g dry weight. These results suggest very little contamination at this site.

2. Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1

At MW-1, the monitoring well installed next to the sewage lagoon (T-1), oil and grease, at 2.5 mg/L, was slightly elevated, while phenolics were below detection limits (see Table 5). TOC, TOX, and pH were within the normal ranges for inferred background levels. Specific conductance, at 2016 μmhos/cm, was within the expected range of conductivity values based on TDS concentrations measured in other base wells. The metals (cadmium, chromium, nickel, and silver) were below detection limits. The eight pesticides were also below detection limits. Of the parameters tested, the oil and grease concentration suggests the ground water may be contaminated at this site.

Analytical results for MW-3, the monitoring well next to the inactive landfill site, D-2, found all parameters tested within normal ranges for expected background levels or undetected.

MW-2, the monitoring well installed next to the active landfill site (D-1), appears to indicate ground water contamination. TOX (93 µg/L), TOC (20 mg/L), and oil and grease (3.6 mg/L) are all above expected background levels. All other tested parameters were within normal ranges; the metals and pesticides were below detection limits.

3. Area 3, Old Jet Fuel Yard Area: Site SP-1

One monitoring well, MW-5, was placed within Site SP-1, the site of numerous small jet fuel spills. Oil and grease was 6.6 mg/L, which suggests the ground water may be contaminated at this area. Specific conductance, TOC, TOX, and pH were within the ranges of normal background levels.

The results of soils analyses at this site are mixed. Oil and grease was detected at levels of 0.023 to 0.033 mg/g dry weight, and TOX was below detection limits. TOC, however, increased with depth from 1490 µg/g dry weight at 5 feet to 1950 µg/g dry weight at 10 feet. At 20 feet, TOC dropped to 150 µg/g dry weight. These results suggest the soil may be contaminated to a depth of between 10 and 20 feet.

4. Area 4, Auto Hobby Shop: Site S-5

Two borings, B-1 and B-2, were placed near an underground waste oil storage tank at the auto hobby shop (Site S-5). Ground water was not sampled at this site. Results of soils analyses at Site S-5 indicate some contamination of the soil at and near the surface with little or no contamination at depth. Oil and grease levels in B-1 and B-2 were 6.3 and 0.95 mg/g, respectively, at the surface and were 0.18 and 0.12 mg/g, respectively, at about 3 feet. Oil and grease were not detected at 10 feet. Lead was higher at the surface than at depth, especially in B-1, ranging from 176 µg/g dry weight at the surface to 26 µg/g dry weight at 10 feet. At the surface, TOC levels were high (5050 to 6560 µg/g) compared to the rest of the soils sampled in this investigation, and, as expected, they dropped with increasing depth. TOX was below detection limits in all the samples at Site S-5.

5. Reliability of Ground Water and Soil Analyses

The ground water quality analyses are considered to be reliable by virtue of the well construction and sampling measures taken in the field to ensure that the samples were representative; by virtue of quality control procedures in the laboratory; and because of the monitoring well locations. The one exception is the group of lead analyses for ground water, which is discussed in Appendix G, Analytical Data.

As described earlier, the monitoring wells were screened above and below the water table where low density organic contaminants would be concentrated. Well construction data are summarized in Table 7; well construction diagrams are presented in Appendix C. After the monitoring wells were installed, they were developed by bailing to minimize the effects of drilling and installation and to facilitate the flow of ground water into the wells. At least three casing volumes of water were removed from the monitoring wells prior to sampling to ensure that the samples were representative of ground water in the formation. The monitoring well samples were collected with a PVC bailer to minimize agitation and consequent aeration of the sample, which could volatilize organic chemicals.

The monitoring wells and soil borings were installed at locations where they would most likely intercept contaminants from the suspected contaminant sites. Locations of the various wells are shown in Plates 11, 12, and 13.

The laboratory quality control (QC) program is described in detail in Appendix E. In general, analyses of duplicate and spiked samples were satisfactory, except the lead analyses for water, where the recovery rate was 4.3 percent. A matrix effect was suspected to be the cause of the low recovery rate.

6. Background Concentrations

No historic background concentrations of organic parameters or pesticides are available for ground water beneath Lowry AFB, but some information exists for concentrations of inorganic constituents. Ground water used around the base is primarily from the surficial and Denver aquifers, with lesser amounts from the Arapahoe and Laramie-Fox Hills aquifers. Water quality in these aquifers is generally good, although dissolved solids are expected to be high, particularly in the surficial aquifer. Additionally, some of the formation waters contain naturally occurring dissolved iron, hydrogen sulfide, and methane gas, which can cause objectionable taste and odors.

TABLE 7

LOWRY AFB
MONITORING WELL CONSTRUCTION DETAILS

WELL	DEPTH[a]	SCREENED INTERVAL[a] FROM	TO	GROUND SURFACE ELEVATION	TOP OF PIPE ELEVATION	WATER TABLE ELEVATION[b]
MW-1	40.0	5.0	40.0	5410.62	5412.53	5407.52
MW-2	40.0	5.0	40.0	5414.29	5415.98	5411.09
MW-3	35.0	5.0	35.0	5431.24	5432.24	5420.84
MW-4	40.0	10.0	40.0	5434.84	5436.48	5417.24
MW-5	40.0	10.0	40.0	5382.21	5384.22	5362.61

[a]Feet below ground surface.

[b]Readings taken on November 5, 1984.

Hillier et al. (1983) and Robson (1984) have reported on the quality of the ground water in the Denver Basin. Table 8 summarizes the quality of the water in the Denver and Arapahoe aquifers in the Denver Basin. State standards for public water supplies are often exceeded in these aquifers, especially for total dissolved solids (TDS), manganese, and sulfate. As discussed in Section II.E, these aquifers generally have about 200 mg/L TDS and less than 25 mg/L dissolved sulfate.

No historic analyses of the organic content of ground water beneath the base were available, and the absence of any water quality criteria for TOX and TOC precludes any regulatory basis for comparing the concentrations obtained from water and soil samples. However, the following information provides some basis for interpreting the quality of water and soil indicated by TOX and TOC measurements.

TOC is a measure of the organic carbon in a sample, regardless of whether the source is natural or man-made. Organic carbon in uncontaminated ground water is derived from humic and fulvic acids dissolved from sediments, dissolution of carbonates containing organic carbon, and other dissolved organic materials. Background concentrations are typically less than 10 mg/L. In an aquifer in which there is little ground water movement, organic-rich aquifer material, and relatively anaerobic or reducing conditions, TOC concentrations could be expected to range up to 100 mg/L. Industrial wastes may contain as much as 200,000 mg/L, and consequently, highly contaminated ground water may yield any concentration including several thousand milligrams of TOC per liter.

All soils contain varying fractions of organic materials that, in turn, contain different concentrations of organic carbon. The organic carbon analyses for the Lowry AFB samples were performed on soil slurried with water and analyzed using the TOC methodology (USEPA Method 415.1) for water. No TOC methodology for solid samples has been approved by USEPA to date. The Lowry AFB soil analyses were evaluated only on a relative basis, as no specific background samples were collected during the Phase II, Stage 1 field effort. Because 22 soil samples were collected and analyzed, a data base, although slim, does allow this type of evaluation to be made.

TOX is a measure of organic halogens containing chlorine, bromine, and iodine that can be adsorbed by activated carbon. The same methodology (USEPA Method 9020) was used for both soil and water analyses. A water extract was taken from the soil samples according to USEPA methods (USEPA, 1982). Chlorinated and brominated organic chemicals are not naturally produced, but are manufactured chemicals such as pesticides, PCBs, PBBs, and solvents. There are no established safe levels of TOX because of the wide variety of compounds that contribute to TOX.

TABLE 8

SUMMARY OF SELECTED CHEMICAL CONSTITUENTS IN WATER FROM WELLS, DENVER BASIN

			DENVER AQUIFER				ARAPAHOE AQUIFER			
			RANGE				RANGE			
CONSTITUENT	UNIT	STANDARD	LOW	HIGH	NUMBER OF SAMPLES	NUMBER OF SAMPLES WHERE STANDARD EXCEEDED	LOW	HIGH	NUMBER OF SAMPLES	NUMBER OF SAMPLES WHERE STANDARD EXCEEDED
Dissolved solids	mg/L	500[a]	175	7110	27	17	343	1920	4	3
Dissolved arsenic	µg/L	50[b]	<1		1	0	<1		1	0
Dissolved chloride	mg/L	250[a]	3.0	3050	27	3	37	85	4	0
Dissolved fluoride	mg/L	1.8[b]	0.2	2.0	8	2	1.0	4.2	4	1
Dissolved iron	µg/L	300[a]	<1	6900	21	3	70	150	3	0
Dissolved magnesium	mg/L	125[a]	0.2	180	20	1	0.2	80	4	0
Dissolved manganese	µg/L	50[a]	<1	12500	19	6	30	100	2	1
Dissolved nitrite plus nitrate as N	mg/L	10[b]	0.00	3.5	27	0	0.00	8.4	4	0
Dissolved selenium	µg/L	10[b]	8		1	0	20		1	1
Dissolved sulfate	mg/L	250[a]	1.7	1190	22	14	3.3	980	4	3
Hardness, as $CaCO_3$	mg/L	none	32	3870	27	--	30	696	4	--

[a]Recommended state standards for public water supplies (Colorado Department of Health, 1971); with exception of magnesium, standards are the same as the recommended federal standards established for public water supplies (U.S. Environmental Protection Agency, 1977); no recommended federal standard for magnesium.

[b]Primary (mandatory) state standards for public water supplies (Colorado Department of Health, 1977); standards are the same as the mandatory federal standards established for public water supplies (U.S. Environmental Protection Agency, 1976); standard for fluoride based on annual average of maximum daily air temperatures in the study area.

Source: Hillier et al., 1983.

B. SIGNIFICANCE OF FINDINGS

This section presents the extent of contamination. Based on material presented above, results described in the previous section, and the hydrogeology described in Section II, this section will present, to the degree possible, the extent of contamination at each site and the risk to human health, if any, that the contamination poses. Human health could be threatened if any water supply wells are contaminated or are in danger of being contaminated. While there are many registered water wells, some of them very shallow, within 1 mile of the base boundaries, there are only a very small number downgradient that possibly could become threatened.

1. Extent of Contamination at Area 1, Fire Training Zone: Sites FT-1 and FT-2

The ground water and soil at Site FT-1 (see Plate 11) appear to be contaminated, as evidenced by the elevated specific conductance, TOC, and TOX in the ground water and the high HNU photoionization meter readings and fuel odor in the soil in B-4. Although the extent of ground water contamination cannot be determined from one well, the potential for contamination is relatively high at this site because the water table is close to the surface (within 18 feet), and the subsurface clayey soils contain interbedded sand layers that could allow lateral movement of contaminants.

Results of the analyses for this investigation do not confirm contamination of the soil at FT-2, although the black, sticky sand found at 9 feet cannot be explained with certainty.

2. Extent of Contamination at Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1

At the sanitary landfill zone, monitoring well MW-2 (see Plate 12) next to the active landfill (D-1) appears to be in an area of contamination, as TOX, TOC, and oil and grease are all above expected background levels. The shallow depth to the water table (about 3 feet) and sandy soil combine to make the potential for ground water contamination high at this site.

Oil and grease concentrations suggest that the shallow aquifer at MW-1 may be contaminated. No evidence of contamination was detected in monitoring well MW-3.

3. Extent of Contamination at Area 3, Old Jet Fuel Yard Area: Site SP-1

The soils at Site SP-1, the old jet fuel yard (Plate 13), appear to be contaminated to between 10 and 20 feet below the surface, as evidenced by elevated TOC results. Ground water, which is approximately 20 feet from the surface, is also contaminated, as indicated by the oil and grease concentration (6.6 mg/L); the extent of ground water contamination cannot be estimated from one well. The subsurface profile, with interbedded sand, clay, and gravel, would likely produce slow vertical contaminant movement but relatively rapid horizontal movement.

4. Extent of Contamination at Area 4, Auto Hobby Shop: Site S-5

Minor amounts of surface contaminants, particularly lead and TOC, have been found at the surface at Site S-5 (Plate 13), but these elevated levels drop off rapidly with depth. The moderately high lead and elevated TOC levels are indicative of spillage/disposal of automotive gasoline and/or used crankcase oil at this site.

5. Extent of Contamination - Drill Cuttings

Containerized drill cuttings from Area 1 and Area 4 were submitted for analysis and tested for ignitability and EP Toxicity to determine whether these cuttings could be a hazardous waste. These analyses are reported on Page 5 of Appendix G, Analytical Data.

The quality control data indicate that only one parameter, barium, had an unacceptably low recovery rate of 55.8 percent for the spiked sample. This low recovery was checked by reanalysis and confirmed. A matrix effect is suspected. However, the levels of barium are 0.9, 4.1, and 0.1 mg/L, so even with the low recovery rate of the spike, the levels are far below the level of 100 mg/L needed to qualify as a hazardous waste. All other parameters had acceptable recoveries. The drill cuttings are not a hazardous waste.

V. ALTERNATIVE MEASURES AND CONCLUSIONS

A. ALTERNATIVE MEASURES

This section describes several alternatives for further defining the possible magnitude of ground water and soil contamination that has been found at Lowry AFB. The alternatives include additional ground water and soil analyses, a resistivity survey, installation of additional wells at the areas of concern and to define ambient conditions, and continued monitoring. Each alternative is discussed below.

Additional ground water analyses for lead are needed. Analytical problems, specifically a recovery rate of less than 5 percent caused by a suspected matrix effect, made results of the ground water analyses uninterpretable. The method of standard additions analysis for lead should eliminate the problems created by the matrix effect and should, therefore, produce meaningful results.

Further ground water analyses should verify the existence and magnitude of the contamination at the base. In particular, TDS should be analyzed for and correlated to specific conductance. Once the relationship between these two parameters has been established, TDS can be accurately estimated using the less costly and quicker specific conductance measurement. At those sites where fuel contamination is the problem, the soluble constituents of fuel — benzene, toluene, and xylene — may be present in the ground water.

1. Area 1, Fire Training Zone: Sites FT-1 and FT-2

As the topography of the fire training area slopes toward the west from this site, the local direction of ground water flow may be toward a more westerly direction than the general gradient for Lowry AFB. An additional five monitor wells positioned in the alluvium could elucidate the local gradient, ambient levels of contaminants, and whether a contaminant plume is migrating from this site. With the gradient determined, analyses would be performed on water from the upgradient and downgradient wells.

If analyses on ground water samples from these wells indicate contamination is migrating from this area, then the installation of additional wells positioned downgradient and plume modeling would be warranted. Also, the results of chemical analyses would determine whether the level of contamination would warrant placing monitoring wells into the Denver Formation aquifer. Data from 1978 (Hillier et al., 1983) indicate that the potentiometric surface of the Denver aquifer in the vicinity of Lowry AFB is at a depth of 100 to 150 feet. From the data analyzed to this point, monitor wells into the Denver aquifer do not appear to be warranted.

If the black sticky sand is encountered during well installation, it could be resampled and further analyzed to determine whether this material is associated with fire training activities. In particular, the material could be analyzed to determine whether it is a petroleum hydrocarbon.

2. Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1

A resistivity survey of the landfill zone could provide a cost-effective subsurface investigation to map the plume(s) from this area. However, the complex interbedded subsurface profile makes the results of such a survey very difficult to interpret and probably precludes its use at Lowry AFB.

Additional wells, one placed in the upgradient direction adjacent to the southern boundary fence and several in the downgradient direction, are needed to determine ambient levels of contaminants and to confirm the existence of a plume at the landfill zone. Two wells positioned in the vicinity of MW-2 will elucidate the local gradient. An additional two wells, spaced at intervals downgradient, will help provide information on potential contaminant migration. If a plume is discovered by analyses on the ground water, then modeling will be needed. To support the modeling efforts, the number of additional wells above the five discussed here would be dependent on the level of contaminants found and specific lithologic conditions encountered during this sequence of well installation.

3. Area 3, Old Jet Fuel Yard Area: Site SP-1

An additional three wells at this site would provide the same needed information as discussed for the previous two areas. An upgradient well would establish ambient levels of contaminants. An additional well in conjunction with MW-5 and the upgradient well would help to establish the local gradient. Once the local gradient is established, a third well placed downgradient from MW-5 would be used to determine whether contaminants are migrating any distance from this site.

4. Background Wells

Although ground water flow directions for the general area are to the north-northwest, the local ground water flow is not well understood. Because Lowry AFB is surrounded by ground water users, an understanding of the local flow system and its relationship to the regional system is very important. Several more wells positioned at a distance from the investigated areas would enable the construction of a potentiometric map for the alluvial aquifer and the determination of ambient levels of contaminants not influenced by specific sites.

B. CONCLUSIONS

This section contains a summary of the conclusions reached after completion of Phase II, Stage 1. Recommendations for the next phase of the IRP are given in Section VI.

Two hydraulically connected aquifers are found at Lowry AFB: the surficial unconsolidated aquifer and the interbedded siltstone and sandstone of the Denver Formation. Ground water flow in these aquifers is generally from the southeast to northwest. At Lowry AFB, a shallow water table and permeable soils produce a likely potential for ground water contamination within the shallow aquifer and a remote potential for contamination within the deeper Denver Aquifer.

The Denver Water Board provides the water supply for Lowry AFB, but there are numerous water wells located within a mile of the base boundaries.

Ground water contamination at Lowry AFB could potentially affect the water supply off the base. The depth to the water table at Lowry AFB is shallow (from 3 to 20 feet), and the subsurface profile includes sands and gravels in which lateral movement of contaminants would be rapid and attenuation would be minimal. There are downgradient ground water users who possibly could be affected by ground water contamination at Lowry AFB.

It should be noted that although the potential exists for contaminant migration to occur off base, there have been no reported off-base contaminanted wells that could be traced to Lowry AFB activities. Because several of the areas investigated have been in use for a long period of time, one would expect that if a problem exists, it would have been detected by this time.

No primary drinking water standards have been found to be exceeded at Lowry AFB during this investigation. Parameters for which there are no drinking water standards, however, indicate some ground water and soil contamination has occurred at the base. In particular, Area 1, Site FT-1, has elevated specific conductance, TOC, and TOX in the ground water and elevated HNU photoionization meter readings and a fuel odor in the soil. Fuel contamination, the likely cause of the contamination at FT-1, is also evident in the soil and ground water at Area 3, Site SP-1. At this site, oil and grease and specific conductance levels were elevated in the ground water; TOC was elevated in the soil. At Area 4, Site S-5, there is some oil and grease contamination and somewhat elevated lead levels in the soil at the surface but little or no contamination at depth.

At Area 2, wells MW-1 and MW-2 appear to be in an area of contamination. Together, these wells have slightly elevated concentrations of one or more of the indicator parameters (TOC, TOX, and oil and grease).

VI. RECOMMENDATIONS

The recommendations presented in this section have two primary purposes:

1. To quantify the magnitude of contamination from each area where contamination has been confirmed; and
2. To aid in establishing the direction, rate, and extent of movement of discovered contaminants.

Various alternative measures for achieving these purposes, along with a discussion of the information that would be obtained, are presented in Section V. The following are our recommendations for areas requiring no further action and areas warranting further investigation.

A. CATEGORY I - AREAS WHERE NO FURTHER ACTION IS REQUIRED

Based on the data gathered in this preliminary investigation, there are no areas where no further action is recommended.

B. CATEGORY II - AREAS WARRANTING FURTHER INVESTIGATION

The lead analyses for all the ground water samples in this study were suspect due to low spike recovery rates, which indicate a matrix effect in the sample analyses. These analyses should be rerun using the method of standard additions to acquire information about lead in ground water at Lowry AFB. No conclusions can be drawn from the results of the first round of lead analyses.

As discussed previously, the local flow regime and its relationship to the regional flow must be better understood to determine where contaminants at Lowry AFB might migrate. In particular, local flow directions, as determined by additional wells, are very important. Additional analyses are needed to confirm the analyses conducted during the present investigation and elucidate whether the water wells within several miles of the base may be potentially within the path of migrating pollutants.

1. Area 1, Fire Training Zone: Sites FT-1 and FT-2

Based on the lithologies encountered and water levels determined during this investigation, it is recommended that five monitor wells be installed near MW-4 such that MW-4 is flanked on the east, south (upgradient), and west by three of the additional monitor wells. The two remaining wells would be positioned at approximately 150- to 200-foot intervals downgradient from MW-4. These wells will be constructed such that the screened interval spans the zone 5 feet above and

15 feet below the water table. The upgradient well will serve to characterize water quality of the area.

Water samples from the existing well MW-4 and the five new monitoring wells should be tested for TDS, specific conductance, pH, temperature, lead, oil and grease, purgeable halocarbons (USEPA Method 601), and purgeable aromatics (USEPA Method 602), plus total xylene.

In addition, a shallow soil boring should be drilled to secure more representative soil samples of the stratum that contained black sticky sand. Two soil samples should be analyzed for oil and grease, petroleum hydrocarbons, and phenolics.

2. Area 2, Sanitary Landfill Zone: Sites D-1, D-2, and T-1

It is recommended that five additional monitor wells be installed, constructed such that the screened interval spans the zone 5 feet above and 15 feet below the water table. The upgradient well would be placed adjacent to the south boundary fence and south of D-1. Two wells would be placed in the vicinity of MW-2 for the purpose of elucidating the local flow gradient and to confirm analyses near MW-2. These wells could help to clarify the width of the plume believed to be detected at MW-2. The final two wells will be placed at intervals of approximately 200 feet downgradient of MW-2.

The significance of elevated specific conductance levels needs to be clarified. To resolve the issue as to what portion of the specific conductance levels is attributable to naturally occurring dissolved solids (such as iron, sulfates, chlorides, manganese) and what portion of the levels is due to contaminants, additional testing encompassing these parameters may be fruitful.

Water samples from MW-2 and the five new monitoring wells should be tested for TDS, specific conductance, iron, sulfates, chlorides, manganese, pH, temperature, lead, oil and grease, purgeable halocarbons (USEPA Method 601), and purgeable aromatics (USEPA Method 602), plus total xylene.

3. Area 3, Old Jet Fuel Yard Area: Site SP-1

Three additional monitoring wells, constructed as those described for the previous two areas, are recommended for Area 3. One well would be placed upgradient of MW-5 and the other two would be placed in the downgradient direction. At this time, it is recommended that MW-5 and the three new wells be analyzed for the same parameters outlined for the previous two areas.

4. Background Wells

To ascertain local ambient conditions, it is recommended that three additional wells be constructed in the same manner as that outlined for the previous sites. One well would be located near the intersection of Old Runway 1 and Old Runway 4, a second would be positioned near the southwest corner of the base near Gate No. 5, and a third would be positioned near the northwest corner of the property. Exact locations would be dependent on site access. These wells would give water level data for the base and help to define ambient levels of contaminants of interest. The ground water would be analyzed for the same parameters as defined for the other areas under investigation.

All monitor wells would be surveyed so that a potentiometric map for the alluvial aquifer could be constructed.

C. CATEGORY III - SITES REQUIRING REMEDIAL ACTION

It is recommended that Area 4, the Auto Hobby Shop, Site S-5, not be included in further investigations. As a prudent measure, it is recommended that base personnel remove surface soil at this site. Based on visual inspection, contaminated soil should be removed in the immediate vicinity of Borings B-1 and B-2 to inhibit the migration of surface contaminants detected in this investigation. Precautions should be taken to avoid future incidents of overfilling the waste oil tank.

Because this site lies within the SPF area, in-situ remedial actions were not believed to be as expeditious in remediating the contamination as a simple removal of the soils.

[lafb4]

APPENDIX A

DEFINITIONS, NOMENCLATURE, AND UNITS OF MEASUREMENT

DEFINITIONS, NOMENCLATURE, AND UNITS OF MEASUREMENT

AFB	Air Force Base
alluvium	Unconsolidated sediments deposited during comparatively recent geologic time by a stream or other body of running water.
alluvial fan	Alluvial material deposited as a cone or fan at the base of a mountain slope.
aquifer	A geologic formation, group of formations, or part of a formation that is capable of yielding water to a well or spring.
aquiclude	A body of relatively impermeable rock that is capable of absorbing water slowly but functions as an upper or lower boundary of an aquifer and does not transmit ground water rapidly enough to supply a well or spring.
aquitard	A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer.
aromatic	Designating cyclic organic compounds characterized by a high degree of stability in spite of their apparent unsaturated bonds and best exemplified by benzene and related structures, but also evident in other compounds.
artesian	Ground water confined under hydrostatic pressure.
as N	As weight of nitrogen
ATC	Air Training Command
AVGAS	Aviation gasoline
cm/sec	Centimeter(s) per second
cone of depression	A depression in the potentiometric surface of a body of water that has the shape of an inverted cone and develops around a well from which water is being withdrawn.
conglomerate	The consolidated equivalent of gravel, both in size range and in the essential roundness and sorting of its constituent particles.
Cretaceous	A period of geologic time thought to have covered the span between 144 and 66.4 million years ago. Also, the corresponding system of rocks.
DDD	Abbreviation for dichlorodiphenyldichloroethane
DDE	Abbreviation for dichlorodiphenyldichloroethylene, a degradation product of DDT.

DDT	Dichlorodiphenyltrichloroethane, an insecticide
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DOD	Department of Defense
downgradient	In the direction of decreasing hydraulic static head; the direction in which ground water flows.
effluent	A liquid waste discharge from a manufacturing or treatment process, in its natural state, or partially or completely treated, that discharges into the environment.
°F	Degrees Fahrenheit
ft	Foot, feet
gpd/ft	Gallon(s) per day per foot
gpm	Gallon(s) per minute
HNU	A type of photoionization detector for measurement of organic vapors
hydraulic gradient	In an aquifer, the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.
in.	Inch, inches
IRP	Installation Restoration Program
LEL	Lower explosive limit
LTTC	Lowry Technical Training Center
matrix effect	The effect caused by the presence of certain constituents (such as chlorides and sulfides when analyzing for lead, or chlorides when analyzing for TOX), that interfere with atomic absorption spectrophotometry analyses. These interferences may result in less than the actual value of the contaminant being detected during analysis.
mg/g	Milligram(s) per gram
mg/L	Milligram(s) per liter
ml	Milliliter(s)
μg/g	Microgram(s) per gram
μg/L	Microgram(s) per liter

Modified Mercalli Intensity Scale	An arbitrary scale of earthquake intensity, ranging from I (detectable only instrumentally) to XII (causing almost total destruction). It is named after Giuseppi Mercalli, the Italian geologist who devised it in 1902. Its adaptation to North American conditions is known as the Modified Mercalli Intensity Scale.
MOGAS	Motor gasoline
monitoring well	A well used to measure ground water levels and to obtain samples.
msl	Mean sea level
No.	Number
NPDES	National Pollutant Discharge Elimination System
OEHL	Occupational and Environmental Health Laboratory
OEHL/TS	Occupational and Environmental Health Laboratory/Technical Services
pH	Negative logarithm of hydrogen ion concentration; measurement of acids and bases.
PCB	Polychlorinated biphenyl; highly toxic to aquatic life; PCBs persist in the environment for long periods of time and are biologically accumulative.
PCBs	Polychlorinated biphenyls
PDWS	Primary drinking water standard(s)
percolation	Movement of moisture by gravity or hydrostatic pressure through interstices of unsaturated rock or soil.
permeability	The property or capacity of a porous rock, sediment, or soil for transmitting a fluid without impairment of the structure of the medium; it is a measure of the relative ease of fluid flow under unequal pressure.
phenols	Any of various acidic compounds analogous to phenol and regarded as hydroxyl derivatives of aromatic hydrocarbons.
piezometer	A well commonly used for instrumentation monitoring of low permeability materials.
POL	Petroleum, oil and lubricants
porosity	The property of a rock, soil, or other material of containing interstices.

potentiometric surface	An imaginary surface representing the static head of ground water and defined by the level to which water will rise in a well.
ppb	Part(s) per billion
ppm	Part(s) per million
Precambrian age	Geologic time before the beginning of the Paleozoic; it is equivalent to about 90 percent of geologic time and ended approximately 570 million years ago.
PVC	Polyvinyl chloride
QC	Quality control
RCRA	Resource Conservation and Recovery Act
Recent	An epoch of geologic time thought to have covered the last 10,000 years.
specific capacity	The rate of discharge of a water well per unit of drawdown, commonly expressed as gallons per minute per foot.
specific conductivity	With reference to the movement of water in soil, a factor expressing the volume of transported water per unit of time in a given area.
STP	Sewage treatment plant
TDS	Total dissolved solids
TOC	Total organic carbon
TOX	Total organic halogens
transmissivity	The rate at which water is transmitted through a unit width under a unit hydraulic gradient.
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
wash	A term applied in the western United States to the broad, shallow, gravelly or stony, normally dry bed of an intermittent stream, often situated at the bottom of a canyon; it is occasionally filled by a torrent of water.
water table	That surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.

APPENDIX B

SCOPE OF WORK

ORDER FOR SUPPLIES OR SERVICES

1. PROC. INSTRUMENT ID NO. (PIIN): F33615-83-D-4002
2. CALL ORDER NO.: 0026
3. DATE OF ORDER*: 84AUG31
5. REQUISITION/PURCHASE REQUEST PROJECT NO.: FY7624-84-01083
6. CERTIFIED FOR NATIONAL DEFENSE UNDER BDC REG 2/DMS REG 1 RATING

Mark all packages & papers with this number.

7. ISSUED BY — CODE FQ8419

DEPARTMENT OF THE AIR FORCE
AIR FORCE SYSTEMS COMMAND
AERONAUTICAL SYSTEMS DIV/PMRSC
WRIGHT-PATTERSON AFB OH 45433
BUYER: DIANA SUCHECKI
PHONE: (513) 255-5633

8. ADMINISTERED BY — CODE S1403A

DCASMA CHICAGO
O'HARE INTERNATIONAL AIRPORT
P.O. BOX 66911
CHICAGO IL 60666

9. CONTRACTOR NAME AND ADDRESS — CODE 1S346 — FACILITY CODE — IF "9" FOR TYPE FACILITIES SEE SECT "K"

DAMES & MOORE
1550 NORTHWEST HIGHWAY
PARK RIDGE IL 60068

(COOK COUNTY)

(312) 297-6120

MAILING DATE
AUG 28 1984
DUPLICATE ORIGINAL

10. MAIL INVOICES TO: U

11. DISCOUNT FOR PROMPT PAYMENT

1ST: N - DAYS — NET DAYS
2ND: - DAYS — OTHER IF "9" SEE SECT "E"
3RD: - DAYS

12A. PURCHASE OFFICE POINT OF CONTACT: LPV/L58/LPV

12B. RESERVED FOR SERVICE AGENCY USE

13. PAYMENT WILL BE MADE BY — CODE S1402A IF "9" SEE SECT "K"

DCASR CHICAGO
O'HARE INTERNATIONAL AIRPORT
P.O. BOX 66475
CHICAGO IL 60666

14. TYPE CONTRACTOR: A
15. SECURITY A. CLAS: U — B. DATE OF DD 254

16. CONTRACT ADMINISTRATION DATA — A. FAST PAY: 0 — B. CONTRACT (1) KIND (2) TYPE: 9 — C. ABSTRACT RECIP ACP POINT — D. SPL CONT PROVISIONS — E. CONT ADMIN FUNC LMT
17. RESERVED
18. SVC AGENCY USE
19. SURV CRIT: C
20. TOTAL AMOUNT: NOT-TO-EXCEED $ 50,299.54

21. APPROPRIATION AND ACCOUNTING DATA
A. SEC CLAS: U — B. ACRN: AA — C. APPROPRIATION: 9740810.200 — D. LIMIT SUBHEAD — E. SUPPLEMENTAL ACCOUNTING CLASSIFICATION: E74 4308 P820 503701
F. CPN RECIPIENT DODAAD — G. OBLIGATION AMOUNT: 50,299.54 — H. NON-CLIN CLIN PAYMENT PROV — I. SVC AGENCY USE: FY7624-84-01083**

22A. DELIVERY: X — B. NON-DOD CONTRACT NO.
This delivery order is subject to instructions contained on this side of form only and is issued in accordance with and subject to terms and conditions of above numbered contract, or Non-DOD Contract No.

PURCHASE — Reference your ~~CONTRACT CATEGORY CODE: FAZ~~

Furnish the following on terms specified herein, including, for U.S. purchases, General Provisions of Purchase Order on DD Form 1155 ... special provisions ... and delivery as indicated. This purchase is negotiated under authority of 10 USC 2304(a)( ) or as specified in the schedule if within the U.S., its possessions or Puerto Rico, if otherwise, under 2304(a)(6).

If checked, Additional General Provisions apply; supplier shall sign Acceptance on DD Form 1155 and return ...

*If quantity accepted by the Government is same as quantity ordered, indicated by ✓ mark. If different, enter actual quantity accepted below quantity ordered and encircle.

23. UNITED STATES OF AMERICA
BY: Christopher D. Miller — 84AUG16 (YYMMMDD)
CHRISTOPHER D. MILLER
NAME OF CONTRACTING/ORDERING OFFICER AND DATE

24. TOTAL
28. DIFFERENCES

25. QUANTITY ORDERED HAS BEEN — INSPECTED — RECEIVED — ACCEPTED AND CONFORMS TO THE CONTRACT EXCEPT AS STATED
26. SHIP NO. — PARTIAL — FINAL
27. D.O. VOUCHER NO.
29. INITIALS
31. PAID BY
32. Amount verified correct for
DATE — SIGNATURE OF AUTHORIZED GOVERNMENT REPRESENTATIVE
30. PAYMENT — COMPLETE — PARTIAL — FINAL
33. CHECK NUMBER
I CERTIFY THIS AMOUNT IS CORRECT AND PROPER FOR PAYMENT
34. BILL OF LADING NO.
SIGNATURE OF AUTHORIZED CERTIFYING OFFICER
36. RECEIVED AT — 37. RECEIVED BY — 38. DATE RECEIVED — 39. TOTAL CONTAINERS — 40. S/R ACCOUNT NUMBER — 41. S/R VOUCHER NO.

AFSC FORM NOV 75 700

*When used as a formal contract this will be the effective date

** 1947 HSG/FMC, Pentagon, WASH DC 20330
AF Form 402, #E7-0A34-3 DTD 31 MAY 84, CH3

REF/UE

PART I SECTION B OF THE SCHEDULE SUPPLIES LINE ITEM DATA	1. PROC INSTRUMENT ID NO. (PIIN) F33615-83-D-4002	2. SPIIN 0026	3. PAGE 2 OF 11

4. ITEM NO. 0001 | 5. QUANTITY* 1 | 6. PURCH UNIT LO | 7. UNIT PRICE $ | 8. TOTAL ITEM AMOUNT* $E29,719.55

9. SCTY CLAS U | 10. ACRN AA | 11. NSN N | 12. FSCM AND PART NUMBER | 13. CIRR

14. SITE CODES A.POA D B.ACP D C.FOB D | 15. NOUN PH II FIELD EVAL AT LOWRY AFB & DATA | 16. SVC/AGENCY USE

17. PR/MIPR DATA FY7624-84-01083-0001 | 18. AUTHORIZED RATE A.PROGRESS PAY % B.RECOUP % | 19. CONTRACT PERCENT FEE % | 20. SVC ID NO. | 21. ITEM/PROJ MGR FY7624

22. 1ST DISCOUNT A. % B.DAYS | 23. 2ND DISCOUNT A. % B.DAYS | 24. 3RD DISCOUNT A. % B.DAYS | 25. NET DAYS | 26. QUANTITY VARIANCE A. OVER % B. UNDER % | 27. TYPE CONTRACT Y | 28. OPR

29. DESCRIPTIVE DATA

ACCOMPLISH PHASE II FIELD EVALUATION AT LOWRY AFB CO IN ACCORDANCE WITH DESCRIPTION OF TASK SET FORTH IN PARAGRAPH I, PAGES 4 THRU 10 OF THIS ORDER WHICH CAN BE PERFORMED THROUGH EXPENDITURE OF THE FOLLOWING LABOR HOURS:

CATEGORY	HOURS
SENIOR LEVEL PROFESSIONAL	151
MID LEVEL PROFESSIONAL	266
TECHNICIAN	208
SUPPORT	155

IN NO EVENT SHALL THE AMOUNT PAID FOR THE NUMBER OF HOURS SPECIFIED EXCEED THE AMOUNT SPECIFIED IN BLOCK 8 ABOVE. FURNISH DATA IN ACCORDANCE WITH ATTACHMENT #1, DD FORM 1423 OF BASIC CONTRACT, AS IMPLEMENTED BY PARAGRAPH VI, PAGE 9 HEREOF.

4. ITEM NO. 0002 | 5. QUANTITY* 1 | 6. PURCH UNIT LO | 7. UNIT PRICE $ | 8. TOTAL ITEM AMOUNT* $E19,975.20

9. SCTY CLAS U | 10. ACRN AA | 11. NSN N | 12. FSCM AND PART NUMBER | 13. CIRR

14. SITE CODES A.POA D B.ACP D C.FOB D | 15. NOUN SUPPORT | 16. SVC/AGENCY USE

17. PR/MIPR DATA FY7624-84-01083-0002 | 18. AUTHORIZED RATE A.PROGRESS PAY % B.RECOUP % | 19. CONTRACT PERCENT FEE % | 20. SVC ID NO. | 21. ITEM/PROJ MGR FY7624

22. 1ST DISCOUNT A. % B.DAYS | 23. 2ND DISCOUNT A. % B.DAYS | 24. 3RD DISCOUNT A. % B.DAYS | 25. NET DAYS | 26. QUANTITY VARIANCE A. OVER % B. UNDER % | 27. TYPE CONTRACT Y | 28. OPR

29. DESCRIPTIVE DATA

SUPPORT OF ITEM 0001.

THE AMOUNT SPECIFIED IN BLOCK 8 ABOVE IS THE MAXIMUM AMOUNT WHICH MAY BE PAID FOR THIS ITEM.

*REPRESENTS NET AMOUNT OF INCREASE/DECREASE WHEN MODIFYING EXISTING ITEM NO

N = NOT APPLICABLE
U = UNDEFINITIZED
NSP = NOT SEPARATELY PRICED

E = ESTIMATED
– (IN QTY AND $) = DECREASE
+ OR – (IN ITEM NO) = ADDITION OR DELETION
CIRR CONTROLLED ITEM RPT RQMT

SITE CODES: S = SOURCE, D = DESTINATION, O = INTERMEDIATE

PART I SECTION B OF THE SCHEDULE
SUPPLIES LINE ITEM DATA

1. PROC INSTRUMENT ID NO. (PIIN): F33615-83-D-4002
2. SPIIN: 0026
3. PAGE 3 OF 11

4. ITEM NO.	5. QUANTITY*	6. PURCH UNIT	7. UNIT PRICE	8. TOTAL ITEM AMOUNT*
0004	1	LO	$	$E604.79

9. SCTY CLAS	10. ACRN	11. NSN	12. FSCM AND PART NUMBER	13. CIRR
U	AA	N		

14. SITE CODES A. POA	B. ACP	C. FOB	15. NOUN	16. SVC/AGENCY USE
D	D	D	CHEM/PHYS ANALYSIS AND DATA	

17. PR/MIPR DATA	18. AUTHORIZED RATE A. PROGRESS PAY	B. RECOUP	19. CONTRACT PERCENT FEE	20. SVC ID NO.	21. ITEM/PROJ MGR
FY7624-84-01083-0004	%	%	%		FY7624

22. 1ST DISCOUNT A.	B. DAYS	23. 2ND DISCOUNT A.	B. DAYS	24. 3RD DISCOUNT A.	B. DAYS	25. NET DAYS	26. QUANTITY VARIANCE A. OVER	B. UNDER	27. TYPE CONTRACT	28. OPR
%		%		%			%	%	J	

29. DESCRIPTIVE DATA

PERFORM CHEMICAL TESTS IN ACCORDANCE WITH DESCRIPTION OF TASK SET FORTH IN PARAGRAPH 1, PAGES 4 THRU 10 OF THIS ORDER AND DELIVER DATA IN ACCORDANCE WITH ATTACHMENT #3, DD FORM 1423, CONTRACT DATA REQUIREMENTS OF BASIC CONTRACT, AS IMPLEMENTED BY PARAGRAPH VI, PAGE 9 HEREOF.

THE AMOUNT SPECIFIED IN BLOCK 8 ABOVE IS THE MAXIMUM AMOUNT WHICH MAY BE PAID FOR THIS ITEM.

4. ITEM NO.	5. QUANTITY*	6. PURCH UNIT	7. UNIT PRICE	8. TOTAL ITEM AMOUNT*
			$	$

9. SCTY CLAS	10. ACRN	11. NSN	12. FSCM AND PART NUMBER	13. CIRR

14. SITE CODES A. POA	B. ACP	C. FOB	15. NOUN	16. SVC/AGENCY USE

17. PR/MIPR DATA	18. AUTHORIZED RATE A. PROGRESS PAY	B. RECOUP	19. CONTRACT PERCENT FEE	20. SVC ID NO.	21. ITEM/PROJ MGR
	%	%	%		

22. 1ST DISCOUNT A.	B. DAYS	23. 2ND DISCOUNT A.	B. DAYS	24. 3RD DISCOUNT A.	B. DAYS	25. NET DAYS	26. QUANTITY VARIANCE A. OVER	B. UNDER	27. TYPE CONTRACT	28. OPR
%		%		%			%	%		

DESCRIPTIVE DATA

*REPRESENTS NET AMOUNT OF INCREASE/DECREASE WHEN MODIFYING EXISTING ITEM NO

N = NOT APPLICABLE
U = UNDEFINITIZED
NSP = NOT SEPARATELY PRICED

E = ESTIMATED
− (IN QTY AND $) = DECREASE
+ OR − (IN ITEM NO) = ADDITION OR DELETION
CIRR: CONTROLLED ITEM RPT RQMT

SITE CODES: S = SOURCE, D = DESTINATION, O = INTERMEDIATE

Installation Restoration Program

Phase II Field Evaluation

Lowry AFB CO

I. Description of Work

The purpose of this task is to determine if environmental contamination has resulted from waste disposal practices, fuel spills and fire training activities at Lowry AFB CO; to provide estimates of the magnitude and extent of contamination, should contamination be found; to identify potential environmental consequences of migrating pollutants; to identify any additional investigations and their attendant costs necessary to properly evaluate the magnitude, extent, and direction of movement of discovered contaminants.

Ambient air monitoring of hazardous and/or toxic material for the protection of contractor and Air Force personnel shall be accomplished when necessary, especialy during the drilling operation.

The presurvey report (mailed under separate cover) and Phase I IRP report (mailed under separate cover) incorporated background and description of the sites for this task. To accomplish the survey effort, the contractor shall take the following steps:

A. General

1. Determine the aerial extent of each site by reviewing available aerial photos of the base, both historical and the most recent panchromatic and infrared, and by field reconnaissance.

2. Locations where surface water, sediment, and core samples are collected shall be marked with a permanent marker, and the location recorded on a site map.

3. A total of five ground-water monitoring wells shall be installed. The exact location of the wells shall be determined in the field.

4. Each ground-water monitoring well shall be constructed of 2-inch I.D. Schedule 40 PVC casing and screen. Each well shall be completed to a depth of at least 20 feet below the water table surface. The screened interval in each well shall consist of 0.010 inch slotted PVC screen depending upon the geologic findings during the drilling operation. The screened interval shall penetrate the water table by 20 feet and extend 5 feet above the water table. A gravel pack or sand pack, as determined as appropriate for the soil formation, shall be emplaced around the well screen. Clean, fine grained sand shall be placed above the gravel pack. Bentonite pellets shall be placed on top of the sand to seal the screened interval, and the seal shall be completed by using a bentonite grout mixture to the surface. Each well shall be provided with a surface grout seal and protective steel casing with locking cap. All wells shall be developed, Water levels measured, and locations surveyed and recorded on a site map.

5. Ground-water monitoring wells shall comply with U.S. EPA publication 330/9-81-002 NEIC Manual for Groundwater/Subsurface Investigations at Hazardous Waste Sites, and State of Colorado requirements for monitoring well installations. All wells will be developed until they produce clear, sand-free water. Only screw type joints shall be used. Glue fittings are not permitted.

6. All water samples shall be analyzed on site by the contractor for pH, temperature, and specific conductance. Sampling, maximum holding time, and preservation of samples shall comply strictly with the following references: Standard Methods for the Examination of Water and Wastewater, 15th Ed. (1980), pp 35-42; ASTM, Part 31, pp 72-82, (1976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp xiii to xix (1979). All water samples shall be analyzed using minimum detection levels, as specified in Attachment 1.

7. The contractor shall split all water samples. One set of samples shall be analyzed by the contractor and the other set of samples shall be forwarded for analysis through overnight delivery to:

USAF OEHL/SA
Bldg 140
Brooks AFB TX 78235

The samples sent to the USAF OEHL/SA shall be accompanied by the following information:

(a) Purpose of sample (analyte)

(b) Installation name (base)

(c) Sample number (on containers)

(d) Source/location of sample

(e) Contract Task Numbers and Title of Project

(f) Method of collection (bailer, suction pump, air-lift pump, etc.)

(g) Volumes removed before sample taken

(h) Special Conditions (use of surrogate standard, special nonstandard preservations, etc.)

(i) Preservatives used

This information shall be forwarded with each sample by properly completing an AF Form 2752 (copy of form and instructions on proper completion mailed under separate cover). In addition, copies of field logs documenting sample collection should accompany the samples. Chain-of-custody records for all samples, field blanks, and quality control duplicates shall be maintained. All contractor QA/QC program analysis results shall be included in the analytical results of draft final report (as specified in Item VI below).

8. Field data collected for each site shall be plotted and mapped. The nature of contamination and the magnitude and potential for contaminant flow within each site to receiving streams and groundwaters shall be determined or estimated. Upon completion of the sampling and analysis, the data shall be tabulated in the next R&D Status Report, as specified in Item VI below.

B. In addition to items delineated in A above, conduct the following specific actions at sites identified on Lowry AFB CO:

1. Site 1. Fire Training Zone (FT-1 and FT-2)

a. Two soil borings shall be drilled at this site, each to a depth of 15 feet below the surface (BLS). These borings shall be centrally located in FT-1 and FT-2. Soil borings shall be completed by utilizing hollow stem augers. Upon withdrawal of augers, the borehole shall be grouted with a bentonite cement mixture from the bottom of the borehole to the ground surface to avoid downward percolation of contaminated material. Soil samples shall be retained for analysis at 2 1/2-foot intervals from the surface to 10 feet (BLS). From 10-15 feet BLS, samples shall be retained for analysis at five foot intervals and at the saturated/unsaturated zone interface. A maximum of eight soil samples shall be analyzed. Each soil sample shall be analyzed for Total Organic Carbons (TOC), Total Organic Halogens (TOX), Oil & Grease-infrared method (O&G/IR) and lead.

b. Install one groundwater monitoring well along the northwestern margin of Fire Training Area 1 (FT-1). The groundwater monitoring well shall be an average of 40 feet in depth; total footage drilled shall not exceed 40 feet. Soil samples shall be retained for analysis at 2 1/2-foot intervals from the surface to 10 feet BLS. From 10-40 feet BLS, samples shall be retained for analysis at 5 foot intervals and at the saturated/unsaturated zone interface. A maximum of four soil samples shall be analyzed. Each soil sample shall be analyzed for TOC, TOX, O&G/IR, and lead.

c. Collect one groundwater sample from the well.

d. The groundwater sample shall be analyzed for TOC, TOX, O&G/IR and lead.

2. Site 2. Landfill Zone (D-1 and D-2)

a. Install three separate downgradient groundwater monitoring wells. One well shall be located within 100 feet of the northwest corner of Sanitary Landfill D-1. The second well shall be located within 100 feet of the northwest corner of Sanitary Landfill D-2. The third well shall be located within 100 feet of the northwest corner of the sewage lagoon. Wells shall be an average of 40 feet in depth. Total footage of these three downgradient groundwater monitoring wells shall not exceed 120 feet.

b. Collect one groundwater sample from each well.

c. Each groundwater sample shall be analyzed for TOC, TOX, O&G/IR, phenols, cadmium, chromium, lead, nickel, and silver, and the pesticides specified in Attachment 1.

3. Site SP-1. Old Jet Fuel Yard

a. Install one groundwater monitoring well northwest of Building 329. The groundwater monitoring well shall be an average of 50 feet in depth; total footage drilled shall not exceed 50 feet. Soil samples shall be retained for analysis at 2 1/2-foot intervals from the surface to 10 feet BLS. From 10-15 feet BLS, samples shall be retained for analysis at 5 foot intervals and at the saturated/unsaturated zone interface. A maximum of four soil samples shall be analyzed.

b. Each soil sample shall be analyzed for TOX, TOX and O&G/IR.

c. Collect one groundwater sample from the well.

d. The groundwater sample shall be analyzed for TOC, TOX and O&G/IR.

4. Site S-5. Auto Hobby Shop

a. Two soil borings shall be drilled at this site, each to a depth of 10 feet BLS. One soil boring shall be placed downgradient of the site. The second soil boring shall be located topographically downhill of the site. Soil samples shall be retained for analysis at 2 1/2-foot intervals from the surface to 10 feet BLS. A maximum of six soil samples shall be analyzed.

b. Each soil sample shall be analyzed for TOC, Tox, O&G/IR and lead.

C. Well Installation and Clean-up

The well boring area shall be cleaned following the completion of each well and boring. Drill cuttings shall be removed and the general area clean. If hazardous waste is generated in the process of well installation, the contractor shall be responsible for proper containerization for eventual government disposal. The contractor shall determine those drill cuttings suspected as being hazardous waste based upon discoloration, odor or organic vapor detection instrument. The contractor shall test two samples of the suspected hazardous waste for EP Toxicity and Ignitability as specified in Attachment 1. Disposal of drill cuttings is not the responsibility of the contractor.

D. Results of all sampling and analysis shall be tabulated and incorporated in the Informal Technical Information report (Sequence 3, Atch 1 and Sequence 2, Atch 3 as specified in Item VI below) and forwarded to USAF OEHL/TS for review.

E. Reporting

1. A draft report delineating all findings of this field investigation shall be prepared and forwarded to the USAF OEHL, as specified in Item VI below, for Air Force review and comment. This report shall include a discussion of the regional site specific hydrogeology, well and boring logs, data from water level surveys, water quality and soil analysis results, available geohydrologic cross sections, groundwater surface and gradient vector maps, and laboratory quality assurance information. The report shall follow the USAF OEHL format (mailed under separate cover).

2. The recommendation section will address each site and list them by categories. Category I will consist of sites where no further action, including remedial action, is required. Data for these sites is considered sufficient to rule out unacceptable health or environmental risks. Category II sites are those requiring additional monitoring or work to quantify or further assess the extent of current or future contamination. Category III sites are sites that will require remedical actions (ready for IRP Phase IV actions). In each case the contractor will summarize or present the results of field data, environmental or regulatory criteria, or other pertinent information supporting these conclusions.

3. Specific requirements, if any, for additional soil borings or for future groundwater monitoring must be identified.

F. Cost Estimates

The contractor shall provide cost estimates for all additional work recommended to permit proper determination of contaminants. The recommendations provided shall include all efforts required to determine the magnitude and direction of movement of discovered contaminants along with an estimate of the time required to accomplish the proposed effort. This information shall be provided in a separately bound appendix to the draft final report.

II. Site Location and Dates:

Lowry AFB CO
Building, Time and
Dates to be established

III. Base Support: None

IV. Government Furnished Property: None

V. Government Points of Contact:

1. 1Lt Maria R. LaMagna
USAF OEHL/TS
Brooks AFB TX 78235
(512) 536-2158
AV [illegible]-2158

2. 2Lt Blaine E. Murphy
USAF Clinic/SGPB
Lowry AFB CO 80230
(303) 370-3176
AV 926-3176

3. LtCol Ronald L. Schiller
HQ ATC/SGPE
Randolph AFB TX 78150
(512) 652-5271
AV 487-5271

VI. In addition to sequence numbers 1, 5 and 10 which are applicable to all orders, the reference numbers below are applicable to this order. Also shown are data applicable to this order:

Sequence No.	Block 10	Block 11	Block 12	Block 13	Block 14
Atch 1					
4	ONE/R	85JAN20	85JAN30	85MAY30	*
3	O/TIME	**	**		2
Atch 3					
2	O/TIME	**	**		2

*Two draft reports will be required. After incorporating Air Force comments concerning the first draft report, the contractor shall supply the USAF OEHL with a second draft report. The report will be forwarded to the applicable regulatory agencies for their comments. The contractor shall supply the USAF OEHL with 20 copies of each draft report and 50 copies plus the original camera-ready copy of the final report.

**Upon completion of analysis

Attachment 1

Levels of Detection

Levels of Detection are for water unless shown otherwise:

Analyte	Analytical Method	Detection Limit	No. Samples
Oil & Grease (IR)	EPA 413.2	100 μg/L (waters); 100 μg/g (soil)	5 W; 22 S
***Total Organic Carbons (TOC)	EPA 415.1	1000 μg/L	5 W; 22 S
***Total Organic Halogens (TOX)	EPA 9020	5 μg/L (waters); 5 μg/g (soil)	5 W; 22S
Phenols	EPA 420.1	1 μg/L (waters); 1 μg/g (soil)	3 W
Cadmium (1)	EPA 213.2	10 μg/L	3 W
Chromium (1)	EPA 218.1	50 μg/L (waters); 5 μg/g (soil)	3 W
Lead (1)	EPA 239.2	20 μg/L (waters); 2 μg/g (soil)	4 W; 18 S
Nickel	EPA 249.1	100 μg/L	3 W
Silver (1)	EPA 272.2	10 μg/L	3 W
EP Toxicity	40 CFR 261.24	*	2
Ignitability	40 CFR 261.21	**	2
Aldrin	Standard 509A	0.02 μg/L	3 W
Chlordane	Standard 509A	0.20 μg/L	3 W
Dieldrin	Standard 509A	0.02 μg/L	3 W
DDT Isomers	Standard 509A	0.02 μg/L	3 W
Endrin (1)	Standard 509A	0.02 μg/L	3 W
Endrin Aldehyde	EPA 608	0.02 μg/L	3 W
Heptachlor	Standard 509A	0.02 μg/L	3 W
Lindane (1)	Standard 509A	0.01 μg/L	3 W

For soils, use detection levels shown above, but report values as micrograms pesticide per gram of soil.

***Detection levels for TOC and TOX must be three times the noise level of the instrument. Laboratory distilled water must show no response. If so, corrections of positive results must be made.

(1) Primary Drinking Water Standard, 40 CRF 141.12

**Determine if sample is ignitable at 140°F or below. If so, it is considered a hazardous waste

*Metal	μg/L of Solution
As	10
Ba	200
Cd	10
Cr	50
Pb	20
Hg	1
Se	10
Ag	10

PART I SECTION F OF THE SCHEDULE
SUPPLIES SCHEDULE DATA

1. PROC INSTRUMENT ID NO. (PIIN): F33615-83-D-4002
2. SPIIN: 0026
3. PAGE 11 OF 11

4. ITEM NO.	5. ACRN	6. TSP PRI	7. MILSTRIP DOC NO. AND SUFFIX	8. CON ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0001	AA					

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY CLAS	15. SHIP TO	16. MARK FOR
A. 85DEC30	A.	A. 1	U	FY7624	
B.	B.	B.			
C.	C.	C.			

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*
D.	D.	D.
E.	E.	E.

17. DESCRIPTIVE DATA

SEE SECTION H (iv) OF BASIC CONTRACT FOR FY7624 ADDRESS.

ALL TECHNICAL EFFORT TO BE COMPLETED NO LATER THAN 85 JAN 20. DATE ABOVE IS DATE FOR GOVERNMENT ACCEPTANCE OF DATA.

DATA TO BE DELIVERED IN ACCORDANCE WITH ATTACHMENT #1, DD FORM 1423, AS IMPLEMENTED BY PARAGRAPH VI, PAGE 9 HEREOF.

4. ITEM NO.	5. ACRN	6. TSP PRI	7. MILSTRIP DOC NO. AND SUFFIX	8. CON ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0002	AA					

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY CLAS	15. SHIP TO	16. MARK FOR
A. 85JAN20	A.	A. 1	U	FY7624	
B.	B.	B.			
C.	C.	C.			

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*
D.	D.	D.
E.	E	E.

17. DESCRIPTIVE DATA

SEE SECTION H (iv) OF BASIC CONTRACT FOR FY7624 ADDRESS.

4. ITEM NO.	5. ACRN	6. TSP PRI	7. MILSTRIP DOC NO. AND SUFFIX	8. CON ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0004	AA					

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY CLAS	15. SHIP TO	16. MARK FOR
A. 85DEC30	A.	A. 1	U	FY7624	
B.	B.	B.			
C.	C.	C.			

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*
D.	D.	C
E.	E.	E.

17. DESCRIPTIVE DATA

SEE SECTION H (iv) OF BASIC CONTRACT FOR FY7624 ADDRESS.

DATA TO BE DELIVERED IN ACCORDANCE WITH ATTACHMENT #3, DD FORM 1423, AS IMPLEMENTED BY PARAGRAPH VI, PAGE 9 HEREOF.

DATE ABOVE IS DATE FOR GOVERNMENT ACCEPTANCE OF DATA.

*REPRESENTS A NET INCREASE/DECREASE WHEN NO + OR – APPEARS AFTER THE ITEM NO
E = ESTIMATED
– (IN QTY) = DECREASE
+ OR – (IN ITEM NO.) = ADDITION OR DELETION

APPENDIX C

WELL COMPLETION LOGS AND GEOLOGICAL DRILLING LOGS

REGISTERED WATER WELLS
VICINITY OF LOWRY AIR FORCE BASE, COLORADO

TOWNSHIP	RANGE	SECTION	ADDRESS	USE[a]	YIELD (gpm)	DEPTH (ft)	DIRECTION	REMARKS[b]
3S	67W	32 NW SE	1950 Magnolia	1	10	80	NE	
3S	67W	32 NW SE	1600 Monaco Pkwy.	6	20	60	N	
3S	67W	34 NE SW	10115 E 23rd	1	3	15	N	1
3S	67W	34 NE SW	1733 Dallas	1	6	80	ENE	
3S	67W	34 NE SW	1770 Dayton	1	1	50	E-N	
3S	67W	34 NW SW	1740 Alton St.	1	8	15	ENE	
3S	67W	34 SE SW	1604 Clayton	1	8	40	ENE	
3S	67W	34 SW SW	1625 Akron	1	8	20	ENE	
3S	67W	34 SW SW	1665 Akron	1	20	21	NE	
3S	67W	34 NW SE	1775 Delmar	1	4	20	NE	
3S	67W	34 NW SE	1788 Elmira	1	10	22	NE	
3S	67W	34 SE SE	1647 Havana	1	7	64	NE	
3S	67W	35 NE NE	2332 Oswego	1	15	58	NE	1
3S	67W	35 NE NE	?	1	20	40	NE	1
3S	67W	35 NE NE	2332 Oswego	1	15	58	NE	1
3S	67W	35 NE NE	?	1	20	40	NE	1
3S	67W	35 NW NE	2301 Newark	1	15	50	NE	1
3S	67W	35 NW NE	2301 Newark	1	15	50	NE	1
3S	67W	35 SE NE	1805 Peoria	1	40	1100	E	2
3S	67W	35 SE NE	2201 Oswego	1	10	44	NE	1
3S	67W	35 SE NE	2241 Oakland	1	16	49	NE	1
3S	67W	35 SE NE	2065 Nome	1	3	?	NE	
3S	67W	35 SE NE	2241 Oakland	1	16	49	NE	1
3S	67W	35 NE SW	1957 Lansing	1	10	50	NE	
3S	67W	35 SW SW	1633 Jamaica	1	?	80	NE	
3S	67W	35 SE SW	1717 Oakland	1	?	?	NE	
3S	67W	35 SE SE	1612 Paris	6	?	20	NE	
4S	67W	02 SW NW	1389 Kenton	1	14	66	NE	
4S	67W	02 SW NW	1141 Joliet	1	3	27	E	
4S	67W	02 NW SW	1000 Hanover St.	1	240	150	E	2
4S	67W	02 NW SW	1092 Jamaica	1	3	25	E	
4S	67W	03 NE NE	1301 Geneva	1	5	17	E	

[a]Use Code:
1 = Domestic including lawn watering
2 = Livestock
3 = Domestic and livestock
4 = Commercial
5 = Industrial
6 = Irrigation (large capacity wells)
7 = Irrigation and stock
8 = Municipal
9 = Others
0 = In-house use

[b]Remarks:
1 = Location off map and not plotted.
2 = Doubtful location.

REGISTERED WATER WELLS

VICINITY OF LOWRY AIR FORCE BASE, COLORADO

TOWNSHIP	RANGE	SECTION	ADDRESS	USE*	YIELD gpm	DEPTH FT	DIRECTION	REMARKS
4S	67W	03 NW NE	1356 Emporia	[illegible]	[illegible]	[illegible]	N	
4S	67W	03 NW NE	1320 Emporia	[illegible]	20	24	N	
4S	67W	03 SE NE	1085 Peoria	[illegible]	35	[illegible]	E	
4S	67W	03 SE NE	1120 Hanover	[illegible]	4	19	E	
4S	67W	03 NE NW	1325 Dayton	[illegible]	[illegible]	25	N	
4S	67W	03 NW NW	1353 Beeler	[illegible]	12	15	N	
4S	67W	03 SE NW	480 Florence	4	3	50	E	2
4S	67W	03 SE NW	1315 Dallas	1	10	50	N	
4S	67W	03 SE NW	1216 Boston	1	10	40	N	
4S	67W	03 NE SE	835 Pontiac	1	12	35	W	2
4S	67W	03 NE SE	1049 S. Havana	1	10	31	E	2
4S	67W	03 NE SE	1025 Galena	1	6	81	E	
4S	67W	03 NE SE	925 Fulton	1	1	75	E	
4S	67W	03 NW SE	941 S. Fulton	1	30	63	E	2
4S	67W	03 NW SE	1065 Emporia	1	12	60	E	
4S	67W	03 NW SE	1101 Florence	1	6	50	E	
4S	67W	04 SE NW	4875 Parker	1	10	100	SE	2
4S	67W	05 NE SW	?	1	5	100	?	
4S	67W	05 NW SW	860 Krameria	1	30	45	W	
4S	67W	05 SE SW	892 S. Krameria	1	10	35	W	2
4S	67W	07 NE SW	5 Cherry	1	3	29	W	1
4	67W	07 SW SE	175 S. Eudora	1	15	30	W	
4S	67W	08 NW SW	100 Jersey	1	7	126	W	
4S	67W	10 NE NE	Conoco	5	18	1007	E	2
4S	67W	11 NE NW	444 Moline	1	?	60	E	
4S	67W	11 NW NW	538 Ironton Ct.	1	?	80	E	
4S	67W	11 NE SW	375 Moline	1	?	100	E	
4S	67W	15 NW NE	?	4	20	41	?	
4S	67W	15 NE SE	10450 E. Exposition	1	20	40	S	
4S	67W	15 SW SE	1000 Elmira	1	20	132	S	2
4S	67W	15 SW SE	982 S. Dayton	1	10	22	S	
4S	67W	15 SE SE	10151 E. Ford Pl.	7	15	268	S	
4S	67W	16 NE SW	730 S. Krameria	1	30	50	S	
4S	67W	16 SW SE	7877 E. Mississippi	1	?	60	S	
4S	67W	16 SW SE	7877 E. Mississippi	1	?	11	S	
4S	67W	16 SW SE	7877 E. Mississippi	1	?	10	S	
4S	67W	16 SW SE	7877 E. Mississippi	6	15	1150	S	
4S	67W	16 SW SE	939 S. Quince	1	?	25	S	
4S	67W	17 SW NE	6831 E. Center	1	20	92	SE	
4S	67W	17 SW NE	680 S. Monaco	1	13	1050	S	
4S	67W	17 NE SW	721 S. Leyden	1	25	40	SE	
4S	67W	17 NW SW	810 S. Monaco	1	15	41	S	
4S	67W	17 SW SW	1040 S. Kearney	1	10	41	S	
4S	67W	17 SE SW	1001 S. Monaco	4	30	46	S	
4S	67W	17 SE SW	7575 Parker Rd.	1	25	38	S	

REGISTERED WATER WELLS
VICINITY OF LOWRY AIR FORCE BASE, COLORADO

TOWNSHIP	RANGE	SECTION	ADDRESS	USE[a]	YIELD (gpm)	DEPTH (ft)	DIRECTION	REMARKS[b]
4S	67W	17 SE SW	6875 Leetsdale	1	40	18	S	
4S	67W	17 SE SE	6875 Leetsdale	1	15	62	S	
4S	67W	17 SE SW	6330 Leetsdale	1	20	31	S	
4S	67W	17 SE SW	1075 S. Locust	1	30	30	S	
4S	67W	17 SE SW	1065 S. Locust	1	30	30	S	
4S	67W	17 NE SE	6767 Leetsdale	4	42	1030	S	
4S	67W	17 NW SE	6625 Parker Road	4	40	36	SE	
4S	67W	17 SW SE	6675 E. Tennessee Ave.	1	30	50	S	
4S	67W	17 SW SE	6675 E. Tennessee Ave.	6	60	44	S	
4S	67W	17 SW SE	?	6	20	33	?	
4S	67W	17 SW SE	6675 E. Tennessee Ave.	1	25	33	S	
4S	67W	17 SW SE	1160 S. Colorado Blvd.	6	150	30	SW	2
4S	67W	17 SE SE	Fairmont Cemetery	4	?	?	S	
4S	67W	17 SE SE	Fairmont Cemetery	6	300	40	S	
4S	67W	17 SE SE	Parker & Oneida	6	421	49	SE	
4S	67W	17 SE SE	1090 S. Oneida	4	100	1020	S	
4S	67W	17 SE SE	1000 S. Oneida	1	421	49	SE	
4S	67W	17 SE SE	1635 S. Monaco	4	60	46	S	2
4S	67W	18 SW NE	Glendale Water	3?	300	46	SW	
4S	67W	18 SW NE	Glendale Water	3 (8)	300	42	SW	
4S	67W	18 SW NE	950 S. Birch	3	700	45	SW	1
4S	67W	18 SW NE	999 S. Clairmont	6	700	64	SW	1
4S	67W	18 NE NW	3504 E. 12th	4	20	54	W	2
4S	67W	18 NE NW	6665 Leetsdale	1	20	1004	SW	1
4S	67W	18 NE NW	4700 E. Alameda	1	7	220	SW	1
4S	67W	18 NE NW	4600 Leetsdale	4	300	43	SW	1
4S	67W	18 NE NW	4425 Leetsdale	4	200	44	SW	1
4S	67W	18 NW NW	2120 E. Colfax	4	75	48	NW	2
4S	67W	18 NW NW	4353 E. Virginia	1	10	30	SW	1
4S	67W	18 NW NW	4353 E. Virginia	6	15	37	SW	1
4S	67W	18 NW NW	4353 E. Virginia	6	700	41	SW	1
4S	67W	18 NW NW	400 S. Colorado Blvd.	4	17	38	SW	1
4S	67W	18 SW NW	3090 Ash	4	30	52	NW	2
4S	67W	18 SE NW	3830 Adams	1	30	49	NW	2
4S	67W	18 NE SW	?	4	30	36	SW	
4S	67W	18 NE SW	?	4	32	1137	SW	
4S	67W	18 NE SW	4413 E. Kentucky	6	35	34	SW	1
4S	67W	18 NE SW	4413 E. Kentucky	4	13	57	SW	1
4S	67W	18 NE SW	?	6	396	51	SW	1
4S	67W	18 NW SW	Kentucky & Colorado	4	33	375	SW	1
4S	67W	18 NW SE	4901 E. Kentucky	6	150	34	SW	1
4S	67W	18 SW SE	1909½ W. Mississippi	4	150	39	SW	2

MAJOR DIVISIONS			GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
[illegible]	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS [illegible]		GW	[illegible]
				GP	[illegible]
	[illegible]	GRAVELS WITH FINES [illegible]		GM	[illegible]
				GC	[illegible]
[illegible]	SAND AND SANDY SOILS	CLEAN SAND [illegible]		SW	[illegible]
				SP	[illegible]
	[illegible]	SANDS WITH FINES [illegible]		SM	[illegible]
				SC	[illegible]
[illegible]	SILTS AND CLAYS	[illegible]		ML	[illegible]
				CL	[illegible]
				OL	[illegible]
[illegible]	[illegible]	[illegible]		MH	[illegible]
				CH	[illegible]
				OH	[illegible]
[illegible]				PT	[illegible]

SOIL CLASSIFICATION CHART

MATERIAL SIZE	PARTICLE SIZE			
	LOWER LIMIT		UPPER LIMIT	
	MILLIMETERS	SIEVE SIZE*	MILLIMETERS	SIEVE SIZE*
SAND				
FINE	.074	#200*	0.42	#40*
MEDIUM	0.42	#40*	2.00	#10*
COARSE	2.00	#10*	4.76	#4*
GRAVEL				
FINE	4.76	#4*	19.1	3/4"*
COARSE	19.1	3/4"*	76.2	3"*
COBBLES	76.2	3"*	304.8	12"*
BOULDERS	304.8	12"*	914.4	36"

*U.S. STANDARD *CLEAR SQUARE OPENINGS

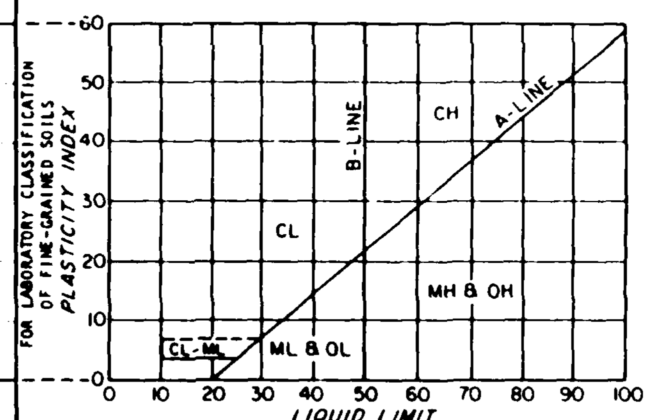
GRADATION CHART

EXPLANATION:

THE NUMBER OF BLOWS REQUIRED TO DRIVE THE 2.0" O.D. BY 1.4" I.D. STANDARD SPLIT SPOON SAMPLER 12" OR LENGTH INDICATED WITH A 140 POUND HAMMER FALLING 30".

15 ▮ DEPTH OF DISTURBED SAMPLE OBTAINED WITH THE SPLIT SPOON SAMPLER.

G - INDICATES GRAB SAMPLE



PLASTICITY CHART

NOTES: 1. DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE CLASSIFICATIONS OR INTERMIXED STRATA.

2. WHEN USED ON THE BORING LOGS, THE FOLLOWING TERMS ARE USED TO DESCRIBE THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE COMPACTNESS OF COHESIONLESS SOILS

COHESIVE SOILS	(APPROXIMATE SHEARING STRENGTH IN KSF)	COHESIONLESS SOILS	
VERY SOFT	LESS THAN 0.25	VERY LOOSE	THESE ARE USUALLY
SOFT	0.25 TO 0.5	LOOSE	BASED ON AN EXAMINATION
MEDIUM STIFF	0.5 TO 1.0	MEDIUM DENSE	OF SOIL SAMPLES,
STIFF	1.0 TO 2.0	DENSE	PENETRATION RESISTANCE,
VERY STIFF	2.0 TO 4.0	VERY DENSE	AND SOIL DENSITY DATA
HARD	GREATER THAN 4.0		

3. WHEN USED ON THE BORING LOGS, THE FOLLOWING TERMS INDICATE THE PERCENTAGES OF THE MINOR SOIL COMPONENTS: SOME, 10 TO 20%; TRACE, 0 TO 10%.

4. ELEVATIONS REFER TO MEAN SEA LEVEL (MSL).

UNIFIED SOIL CLASSIFICATION SYSTEM AND KEY TO LOG OF BORINGS

Dames & Moore

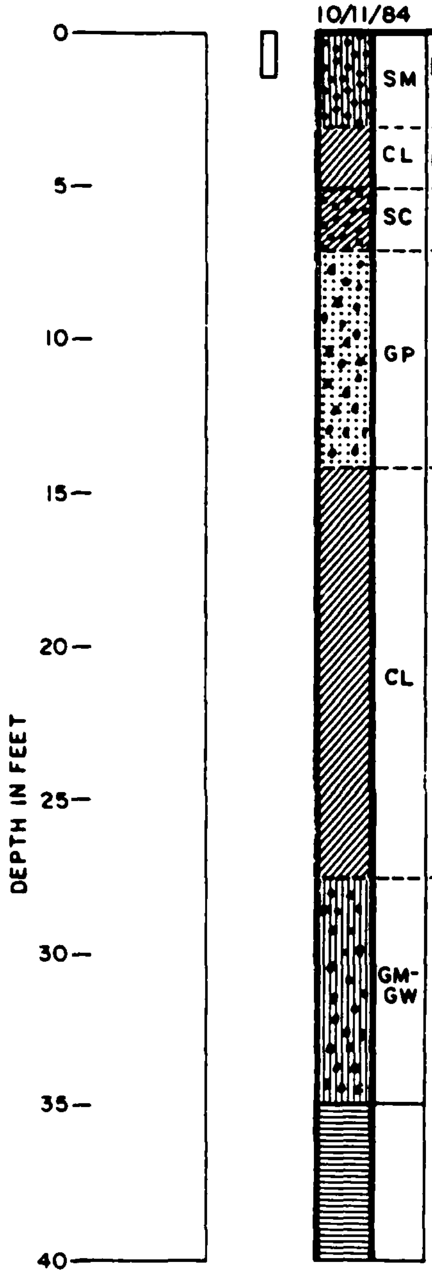
PLATE C-1

LOWRY AFB

BORING MW-1, SEWAGE LAGOON, AREA 2

10/11/84

0.0'



BROWN, SILTY SAND

CLAY

CLAY WITH TRACE OF FINE SAND

FINE TO COARSE SAND WITH SOME SANDY CLAY LENSES

CLAY WITH TRACE OF SAND

MOIST

GRAVEL LENSE

CLAYSTONE

T.D. AT 40' IN CLAYSTONE. GROUND WATER NOT ENCOUNTERED DURING DRILLING.

NOTE: ALL SOIL DESCRIPTIONS TAKEN FROM CUTTINGS OBSERVATIONS.

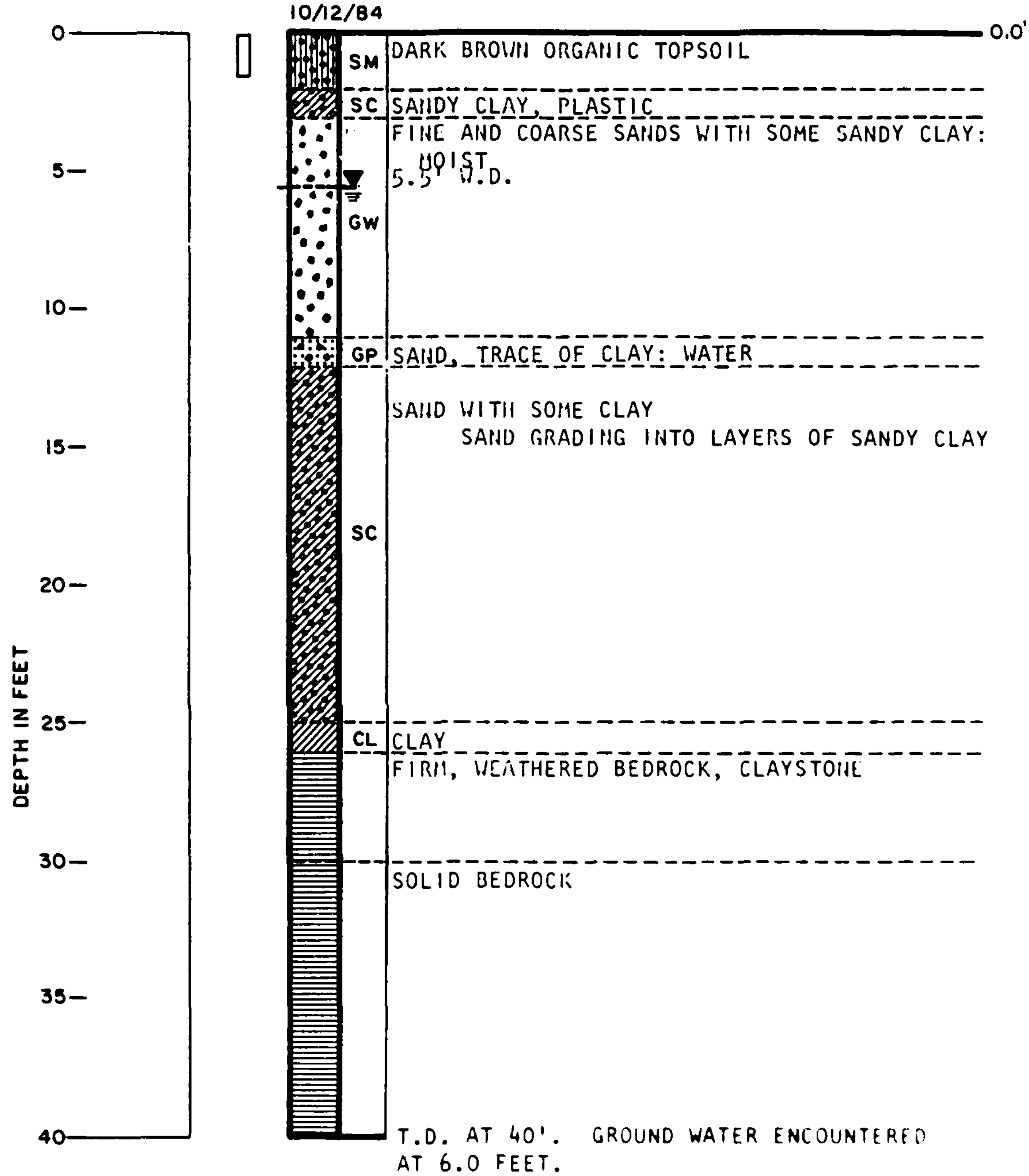
LOG OF BORING

Dames & Moore

PLATE C-2

LOWRY AFB

BORING MW-2, LANDFILL D-1, AREA 2

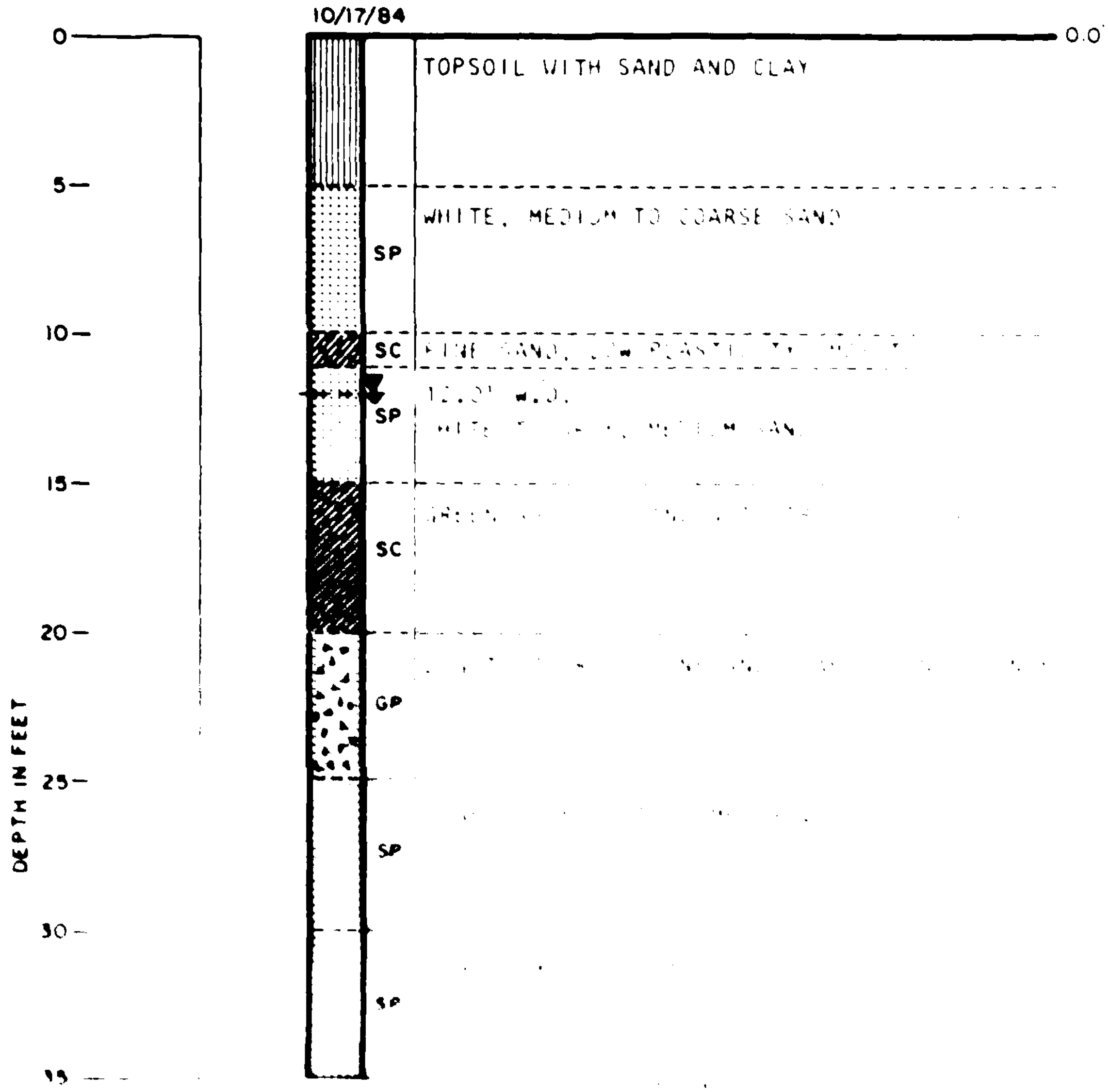


NOTE: ALL SOIL DESCRIPTIONS TAKEN FROM CUTTINGS OBSERVATIONS.

LOG OF BORING

Dames & Moore

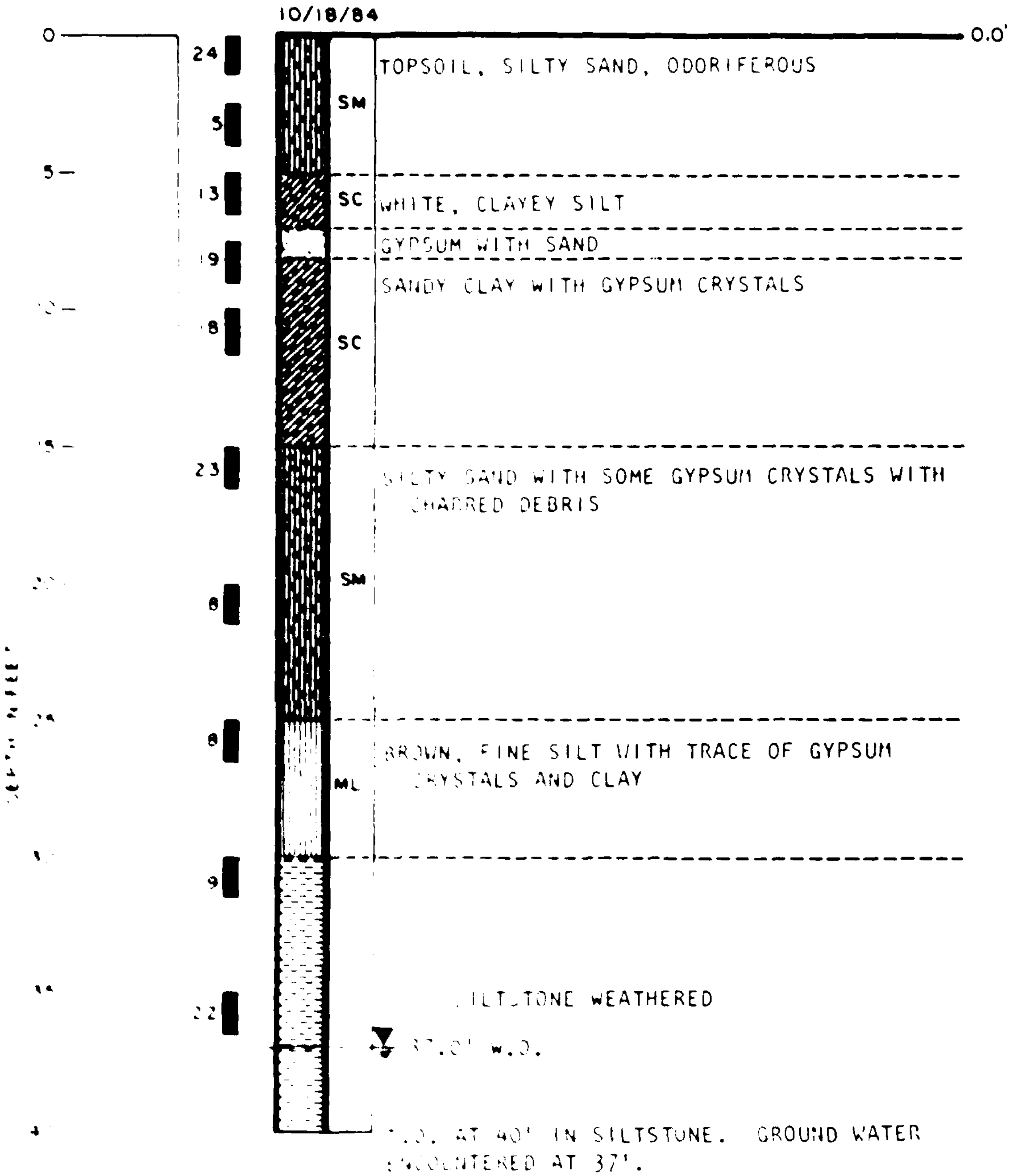
LOWRY AFB
BORING MW-3, LANDFILL D-2, AREA 2



LOG OF BORING

Dames & Moore

LOWRY AFB
BORING MW-4, FT-1, AREA 1

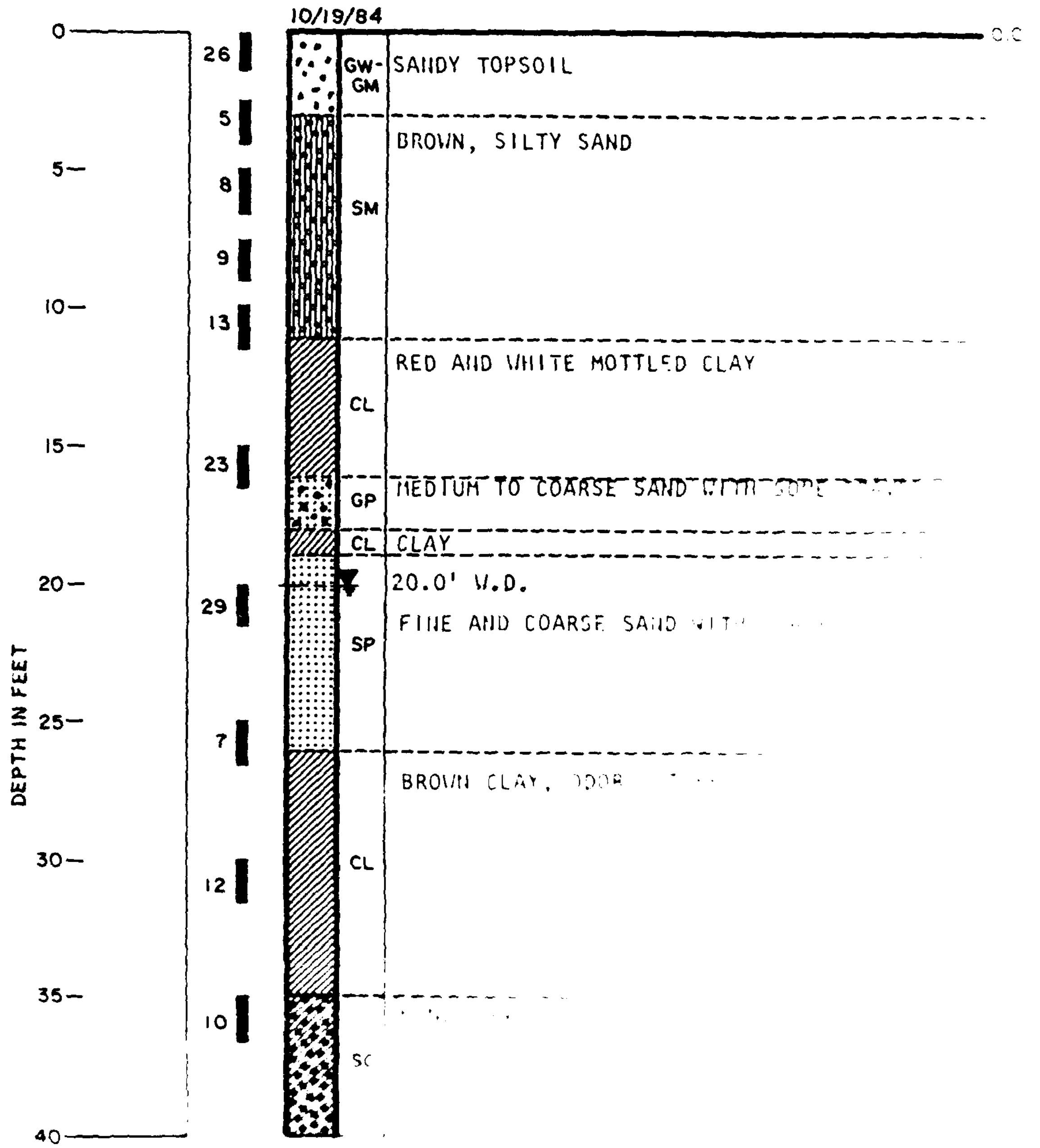


LOG OF BORING

Dames & Moore

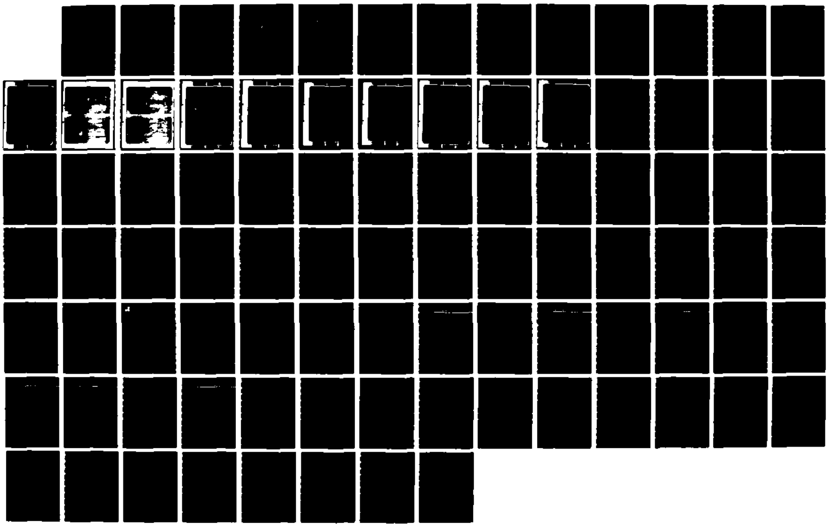
PLATE

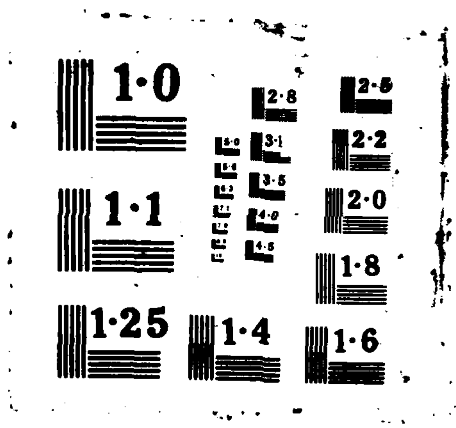
LOWRY AFB
BORING MW-5, SP-1, AREA 3



AD-A176 723 INSTALLATION RESTORATION PROGRAM PHASE II CONFIRMATION/QUANTIFICATION STAGE 1(U) DAMES AND MOORE PARK RIDGE IL 09 JAN 87 F33615-83-D-4002 2/2

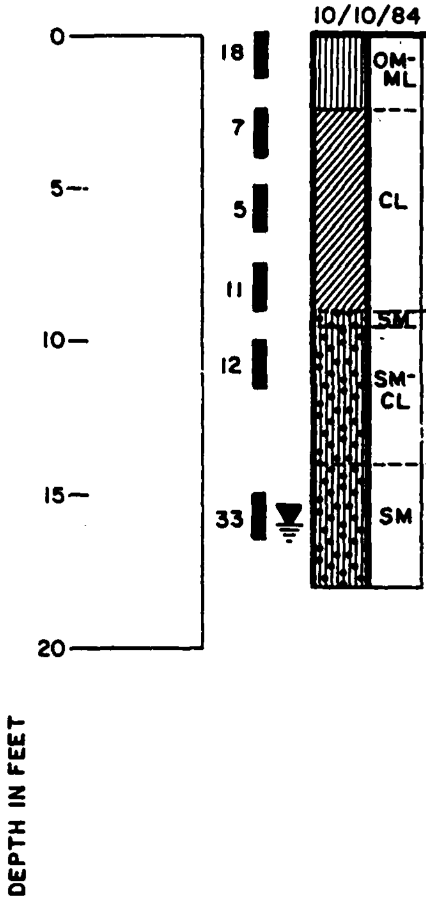
UNCLASSIFIED F/G 13/2 NL




1·0
1·1
1·25
1·4
1·6
1·8
2·0
2·2
2·5
2·8
3·2
3·6
4·0

LOWRY AFB

BORING B-3, FT-2, AREA 1



0.0'

BROWN, SANDY SOIL, ROOTS

BROWN, SILTY CLAY: MOIST

BLACK, STICKY COARSE SAND, SOME SILT, WET

GRAYISH-BROWN CLAY WITH YELLOWISH-GREEN CRYSTALS (GYPSUM)

16.0' W.O.

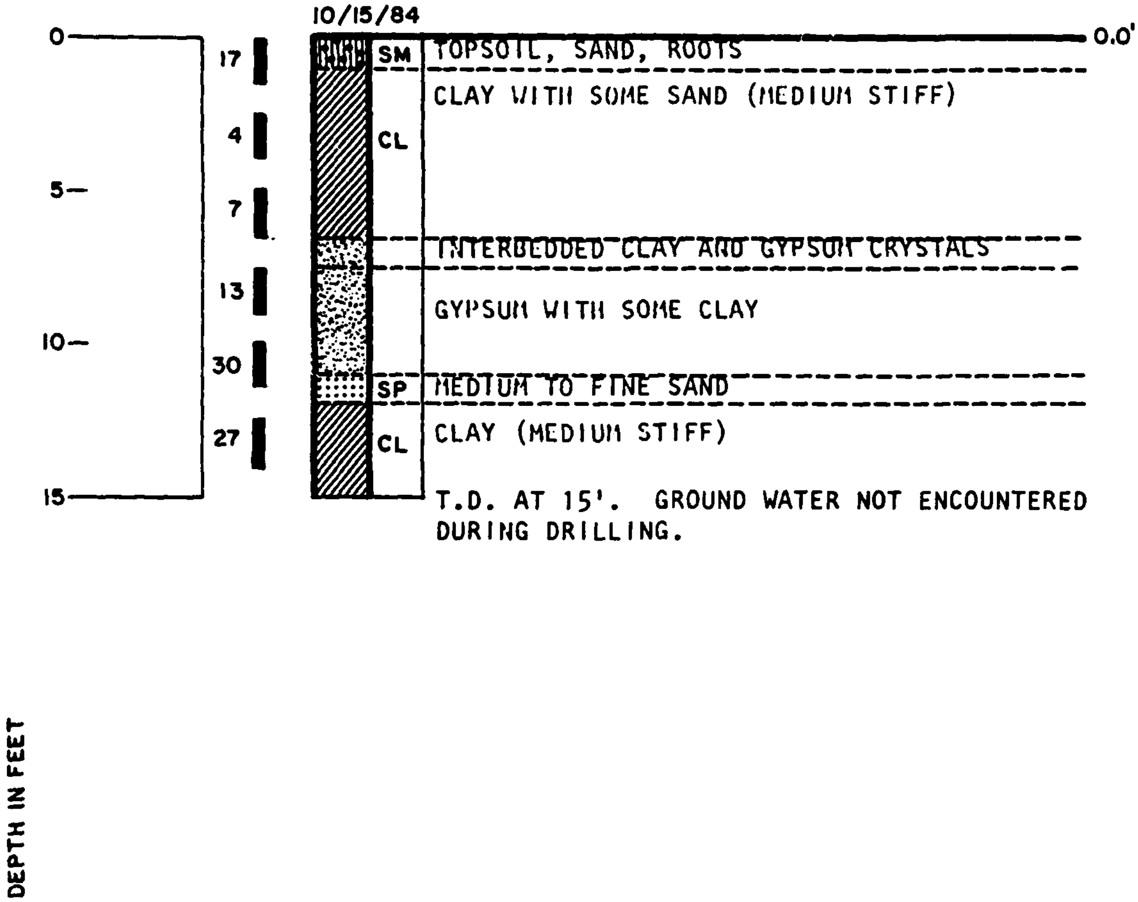
GREEN AND TAN INTERBEDDED, SILTY SANDS AND CLAYS WITH OCCASIONAL RUST-COLORED LENSES AND OCCASIONAL SLICKENSIDES LINED WITH BLACK ORGANIC MATERIALS.

T.D. AT 18'. GROUND WATER ENCOUNTERED AT 16'.

LOG OF BORING

Dames & Moore

LOWRY AFB
BORING B-4, FT-1, AREA 1

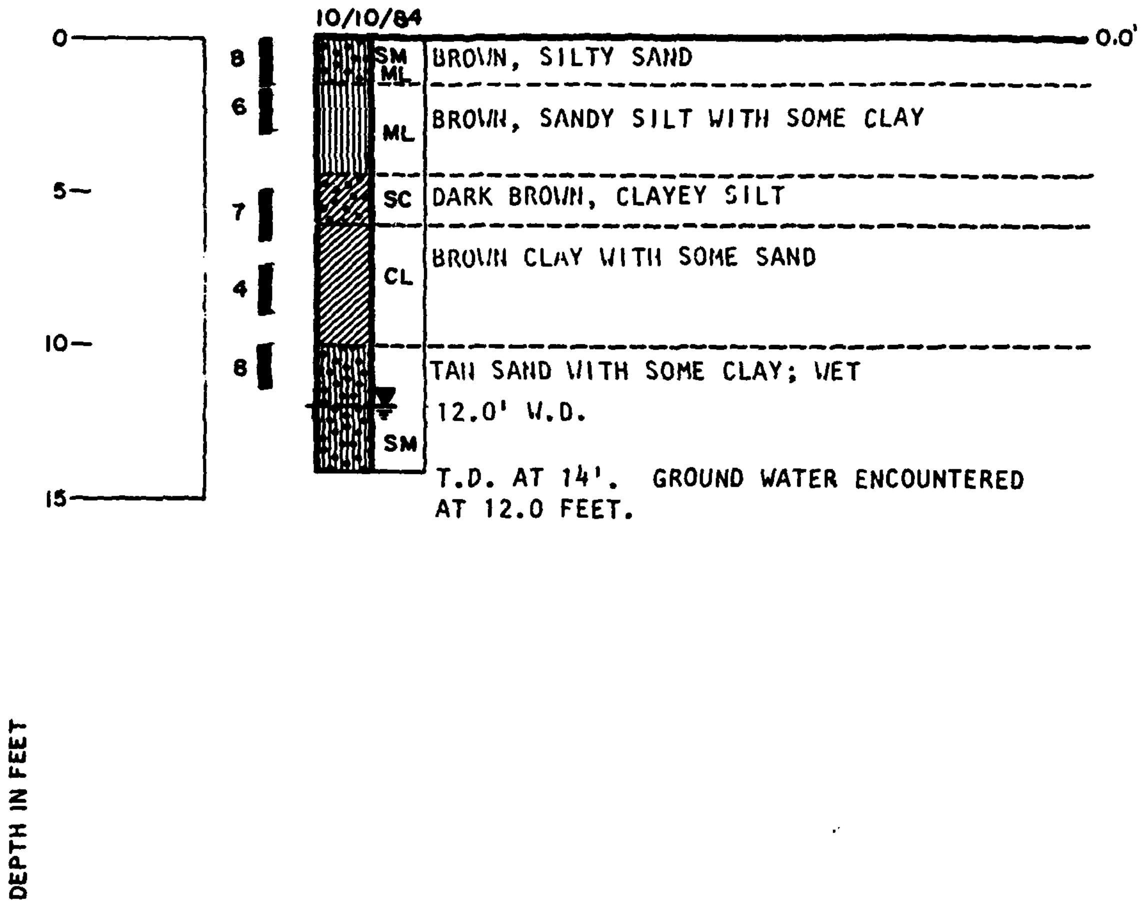


LOG OF BORING

Dames & Moore

PLATE C-8

LOWRY AFB
BORING B-1, S-5, AREA 4

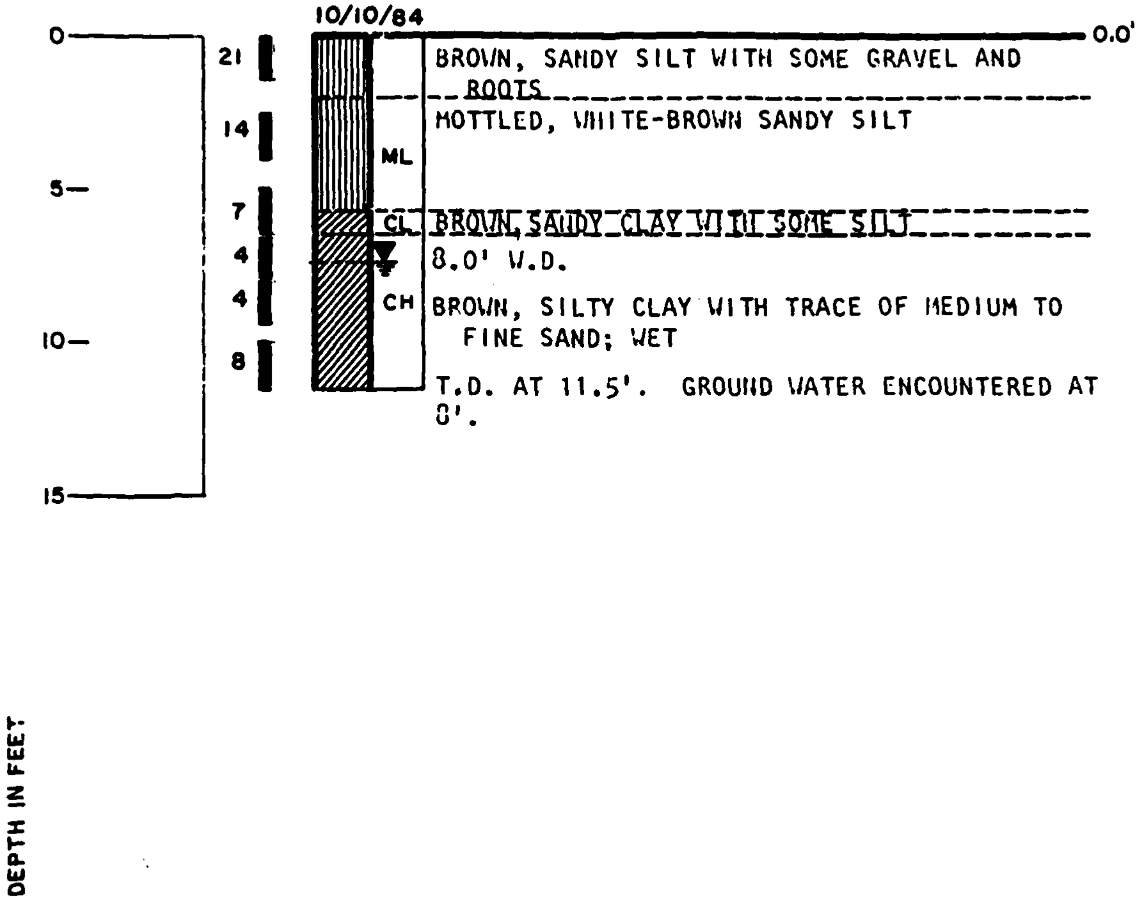


LOG OF BORING

Dames & Moore

PLATE C-9

LOWRY AFB
BORING B-2, S-5, AREA 4



LOG OF BORING

Dames & Moore

PLATE C-10

PIEZOMETER DETAIL INFORMATION SHEET

GROUND SURFACE ELEVATION 5410.62

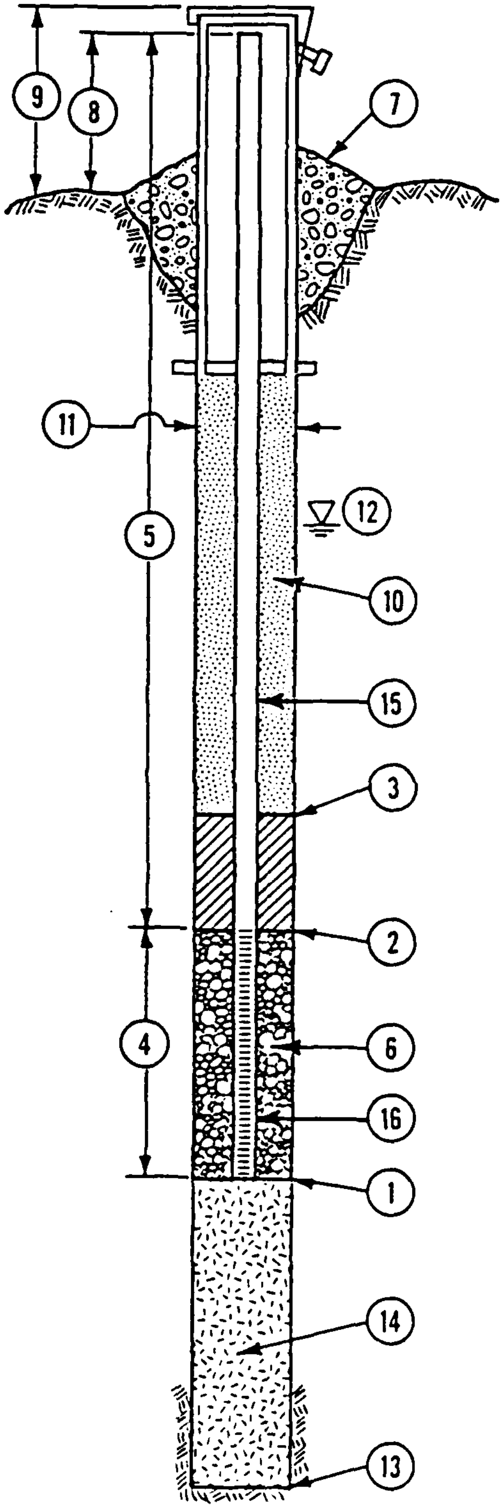
TOP OF WELL CASING ELEVATION 5412.53

JOB NUMBER 1016-217-14

BORING NUMBER MW-1

DATE 10/11/84

LOCATION NEAR SEWAGE LAGOON



1. DEPTH TO BOTTOM OF WELL POINT OR SLOTTED PIPE 40.0 FEET.*
2. DEPTH TO BOTTOM OF SEAL (IF INSTALLED) 4.5 FEET.*
3. DEPTH TO TOP OF SEAL (IF INSTALLED) 1.5 FEET.*
4. LENGTH OF WELL SCREEN 35 FEET. SLOT SIZE 0.01.
5. TOTAL LENGTH OF PIPE 7 FEET AT 2 INCH DIAMETER.
6. TYPE OF PACK AROUND WELL POINT OR SLOTTED PIPE WASHED PEA GRAVEL WITH 1 FOOT OF SAND
7. CONCRETE CAP. YES NO (CIRCLE ONE)
8. HEIGHT OF WELL CASING ABOVE GROUND 2 FEET.
9. PROTECTIVE CASING? YES NO (CIRCLE ONE)
   HEIGHT ABOVE GROUND 2 FEET.
   LOCKING CAP? YES NO (CIRCLE ONE)
10. TYPE OF UPPER BACKFILL CEMENT-BENTONITE GROUT
11. BOREHOLE DIAMETER 8 INCHES.
12. DEPTH TO GROUND WATER 6 FEET.*
13. TOTAL DEPTH OF BOREHOLE 40 FEET.*
14. TYPE OF LOWER BACKFILL none.
15. PIPE MATERIAL PVC.
16. SCREEN MATERIAL PVC.

*(DEPTH FROM GROUND SURFACE, DURING INSTALLATION)

PIEZOMETER INSTALLATION DETAILS

Dames & Moore

PLATE C-11

PIEZOMETER DETAIL INFORMATION SHEET

GROUND SURFACE ELEVATION 5414.29

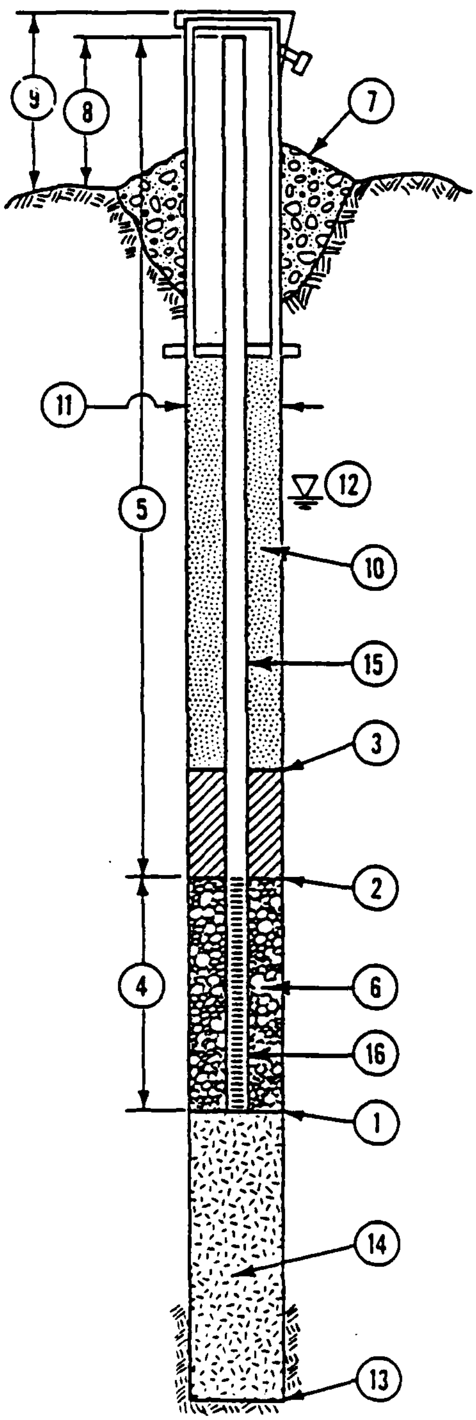
TOP OF WELL CASING ELEVATION 5415.98

JOB NUMBER 1016-217-14

BORING NUMBER MW-2

DATE 10/12/84

LOCATION NEAR D-1 LANDFILL



1. DEPTH TO BOTTOM OF WELL POINT OR SLOTTED PIPE 40.0 FEET. *
2. DEPTH TO BOTTOM OF SEAL (IF INSTALLED) 4.5 FEET. *
3. DEPTH TO TOP OF SEAL (IF INSTALLED) 1.5 FEET. *
4. LENGTH OF WELL SCREEN 35 FEET. SLOT SIZE 0.01.
5. TOTAL LENGTH OF PIPE 7 FEET AT 2 INCH DIAMETER.
6. TYPE OF PACK AROUND WELL POINT OR SLOTTED PIPE WASHED PEA GRAVEL AND 1 FOOT OF SAND.
7. CONCRETE CAP. YES NO (CIRCLE ONE)
8. HEIGHT OF WELL CASING ABOVE GROUND 1.5 FEET.
9. PROTECTIVE CASING? YES NO (CIRCLE ONE) HEIGHT ABOVE GROUND 2 FEET. LOCKING CAP? YES NO (CIRCLE ONE)
10. TYPE OF UPPER BACKFILL CEMENT-BENTONITE GROUT
11. BOREHOLE DIAMETER 8 INCHES.
12. DEPTH TO GROUND WATER 6 FEET. *
13. TOTAL DEPTH OF BOREHOLE 40 FEET. *
14. TYPE OF LOWER BACKFILL NONE.
15. PIPE MATERIAL PVC.
16. SCREEN MATERIAL PVC.

* (DEPTH FROM GROUND SURFACE, DURING INSTALLATION)

PIEZOMETER INSTALLATION DETAILS

Dames & Moore

PLATE C-12

PIEZOMETER DETAIL INFORMATION SHEET

GROUND SURFACE ELEVATION 5431.24

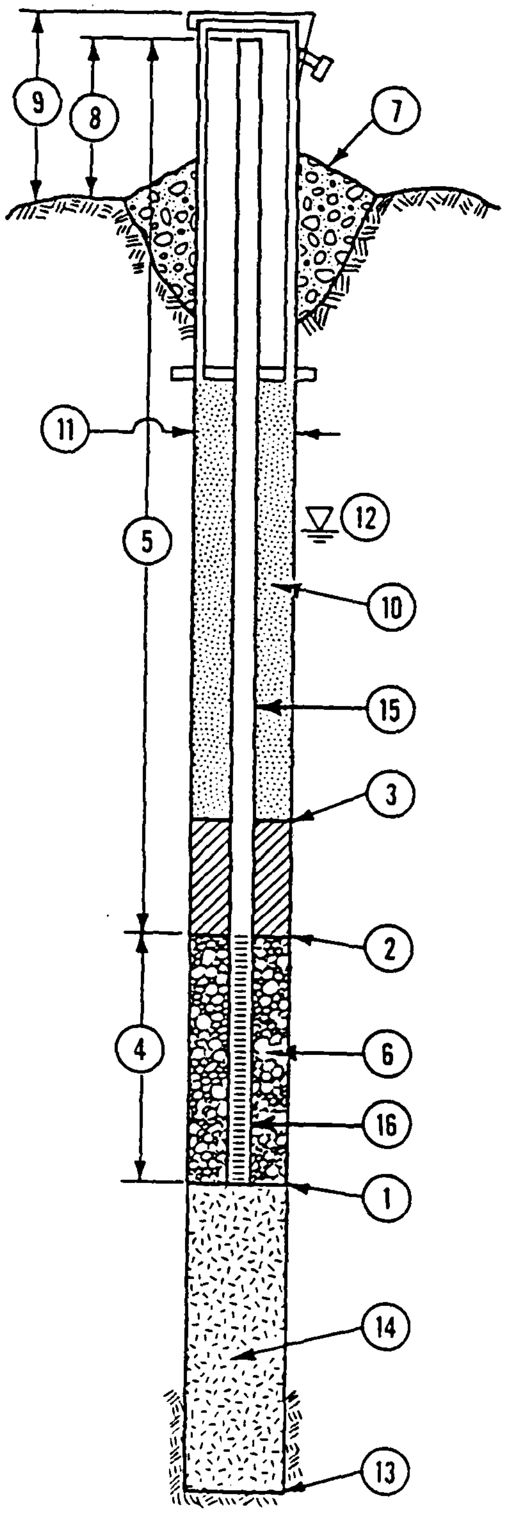
TOP OF WELL CASING ELEVATION 5432.24

JOB NUMBER 1016-217-14

BORING NUMBER MW-3

DATE 10/17/84

LOCATION NEAR D-2 LANDFILL



1. DEPTH TO BOTTOM OF WELL POINT OR SLOTTED PIPE \35 FEET.*
2. DEPTH TO BOTTOM OF SEAL (IF INSTALLED) 4.5 FEET.*
3. DEPTH TO TOP OF SEAL (IF INSTALLED) 1.5 FEET.*
4. LENGTH OF WELL SCREEN \30 FEET. SLOT SIZE 0.01.
5. TOTAL LENGTH OF PIPE 6 FEET AT 2 INCH DIAMETER.
6. TYPE OF PACK AROUND WELL POINT OR SLOTTED PIPE WASHED PEA GRAVEL AND 1 FOOT OF SAND.
7. CONCRETE CAP. YES NO (CIRCLE ONE) — YES circled
8. HEIGHT OF WELL CASING ABOVE GROUND 1.0 FEET.
9. PROTECTIVE CASING? YES NO (CIRCLE ONE) — YES circled
   HEIGHT ABOVE GROUND 2.0 FEET.
   LOCKING CAP? YES NO (CIRCLE ONE) — YES circled
10. TYPE OF UPPER BACKFILL CEMENT-BENTONITE GROUT
11. BOREHOLE DIAMETER 8 INCHES.
12. DEPTH TO GROUND WATER 10.5 FEET.*
13. TOTAL DEPTH OF BOREHOLE 35 FEET.*
14. TYPE OF LOWER BACKFILL NONE.
15. PIPE MATERIAL PVC.
16. SCREEN MATERIAL PVC.

*(DEPTH FROM GROUND SURFACE, DURING INSTALLATION)

PIEZOMETER INSTALLATION DETAILS

Dames & Moore

PLATE C-13

PIEZOMETER DETAIL INFORMATION SHEET

GROUND SURFACE ELEVATION 5434.84

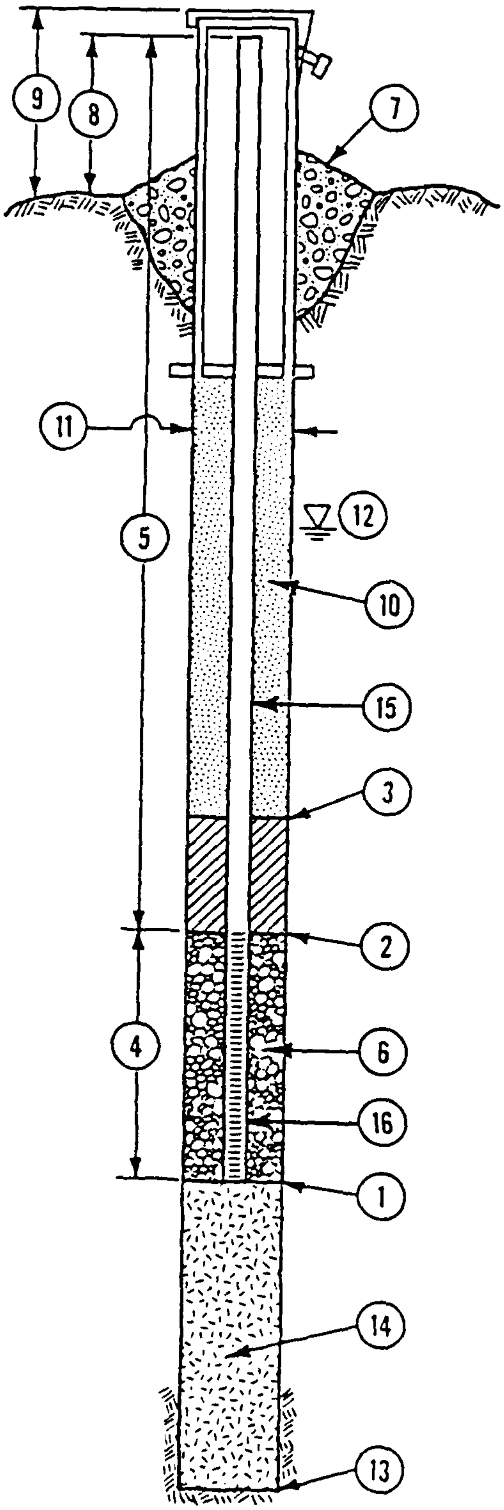
TOP OF WELL CASING ELEVATION 5436.48

JOB NUMBER 1016-217-14

BORING NUMBER MW-4

DATE 10/18/84

LOCATION FTA



1. DEPTH TO BOTTOM OF WELL POINT OR SLOTTED PIPE 40 FEET. *
2. DEPTH TO BOTTOM OF SEAL (IF INSTALLED) 7 FEET. *
3. DEPTH TO TOP OF SEAL (IF INSTALLED) 2 FEET. *
4. LENGTH OF WELL SCREEN 30 FEET. SLOT SIZE 0.01.
5. TOTAL LENGTH OF PIPE 12 FEET AT 2 INCH DIAMETER.
6. TYPE OF PACK AROUND WELL POINT OR SLOTTED PIPE WASHED PEA GRAVEL WITH 1 FOOT OF SAND.
7. CONCRETE CAP. YES NO (CIRCLE ONE)
8. HEIGHT OF WELL CASING ABOVE GROUND 1.6 FEET.
9. PROTECTIVE CASING? YES NO (CIRCLE ONE) HEIGHT ABOVE GROUND 2 FEET. LOCKING CAP? YES NO (CIRCLE ONE)
10. TYPE OF UPPER BACKFILL CEMENT-BENTONITE GROUT.
11. BOREHOLE DIAMETER 8 INCHES.
12. DEPTH TO GROUND WATER 39 FEET. *
13. TOTAL DEPTH OF BOREHOLE 40 FEET. *
14. TYPE OF LOWER BACKFILL NONE.
15. PIPE MATERIAL PVC.
16. SCREEN MATERIAL PVC.

* (DEPTH FROM GROUND SURFACE, DURING INSTALLATION)

PIEZOMETER INSTALLATION DETAILS

Dames & Moore

PIEZOMETER DETAIL INFORMATION SHEET

GROUND SURFACE ELEVATION 5382.21

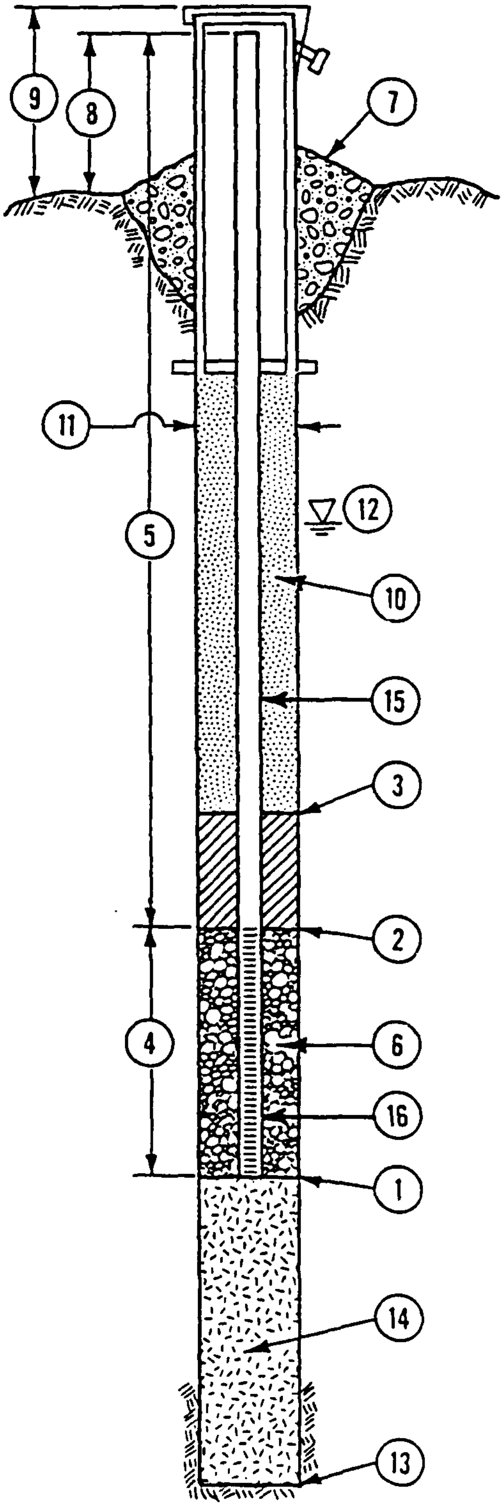
TOP OF WELL CASING ELEVATION 5384.22

JOB NUMBER 1016-217-14

BORING NUMBER MW-5

DATE 10/19/84

LOCATION Site SP-1



1. DEPTH TO BOTTOM OF WELL POINT OR SLOTTED PIPE 40.0 FEET.*
2. DEPTH TO BOTTOM OF SEAL (IF INSTALLED) 7.0 FEET.*
3. DEPTH TO TOP OF SEAL (IF INSTALLED) 2.0 FEET.*
4. LENGTH OF WELL SCREEN 30 FEET. SLOT SIZE 0.01.
5. TOTAL LENGTH OF PIPE 11.5 FEET AT 2 INCH DIAMETER.
6. TYPE OF PACK AROUND WELL POINT OR SLOTTED PIPE washed pea gravel and 1 foot of sand.
7. CONCRETE CAP. YES NO (CIRCLE ONE)
8. HEIGHT OF WELL CASING ABOVE GROUND 2 FEET.
9. PROTECTIVE CASING? YES NO (CIRCLE ONE)
   HEIGHT ABOVE GROUND 2 FEET.
   LOCKING CAP? YES NO (CIRCLE ONE)
10. TYPE OF UPPER BACKFILL cement-bentonite grout.
11. BOREHOLE DIAMETER 8 INCHES.
12. DEPTH TO GROUND WATER 20 FEET.*
13. TOTAL DEPTH OF BOREHOLE 40 FEET.*
14. TYPE OF LOWER BACKFILL none.
15. PIPE MATERIAL PVC.
16. SCREEN MATERIAL PVC.

*(DEPTH FROM GROUND SURFACE, DURING INSTALLATION)

PIEZOMETER INSTALLATION DETAILS

Dames & Moore

PLATE C-15

APPENDIX D

FIELD RAW DATA AND SURVEY DATA

MERRICK

DAMES & MOORE
FEB 19 1985
PARK RIDGE IL

December 21, 1984

Ref: 257-5338

Mr. Steve Werner
Dames & Moore
1626 Cole Blvd.
Golden, Colorado 80401

Dear Steve:

Enclosed is a list of elevations for the wells at Buckley Air National Guard Base and Lowry Air Force Base. Photocopies of all field notes with sketches and ties to the wells and borings are also included.

It has been a pleasure to serve you on this project.

Please call us if you should have any questions on this matter, or require any further services.

Respectfully

Nelson O'Connor

Nelson O'Connor, P.L.S.
Project Manager

NO'C/cjw

Enclosures

Merrick & Company: Engineers & Architects • P.O. Box 22026 • Denver, Colorado 80222 • Telephone: 303/751-0741

December 21, 1984

Ref: 257-5338

WELL ELEVATIONS

Buckley Air National Guard Base

Number	Elevation	Note
MW 1	5549.85	Top of PVC
MW 1	5547.08	Ground
MW 2	5560.58	Top of PVC
MW 2	5558.14	Ground
MW 3	5520.59	Top of PVC
MW 3	5517.94	Ground
MW 4	5517.80	Top of PVC
MW 4	5515.37	Ground

Lowry Air Force Base

Number	Elevation	Note
MW 1	5412.53	Top of PVC
MW 1	5410.62	Ground
MW 2	5415.98	Top of PVC
MW 2	5414.29	Ground
MW 3	5432.24	Top of PVC
MW 3	5431.24	Ground
MW 4	5436.48	Top of PVC
MW 4	5434.84	Ground
MW 5	5384.22	Top of PVC
MW 5	5382.21	Ground

COLORADO REGISTERED
NELSON L. O'CONNOR
22100
PROFESSIONAL LAND SURVEYOR

12-21-84

942/9

JOB # 257-5338 B-2

HORIZ. AND VERT. CONTROL

FOR TESTHOLES @ [redacted]

AIR FORCE BASE

12/18/84

CREW: Dx BURGETT

TØ JACKSON

WILD T-1A-25

WILD NA-2 B-28

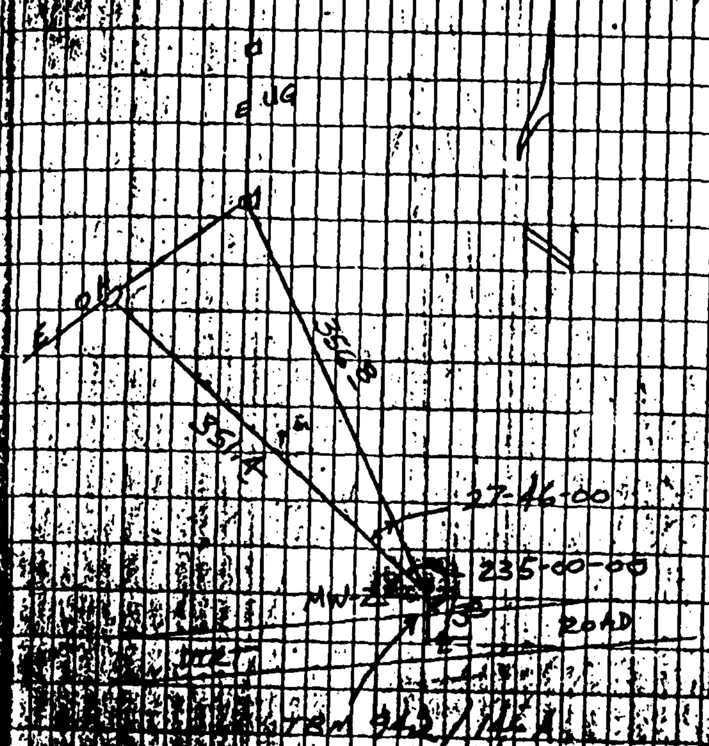
TOPCON DMC2 C-15

35°F CLEAR

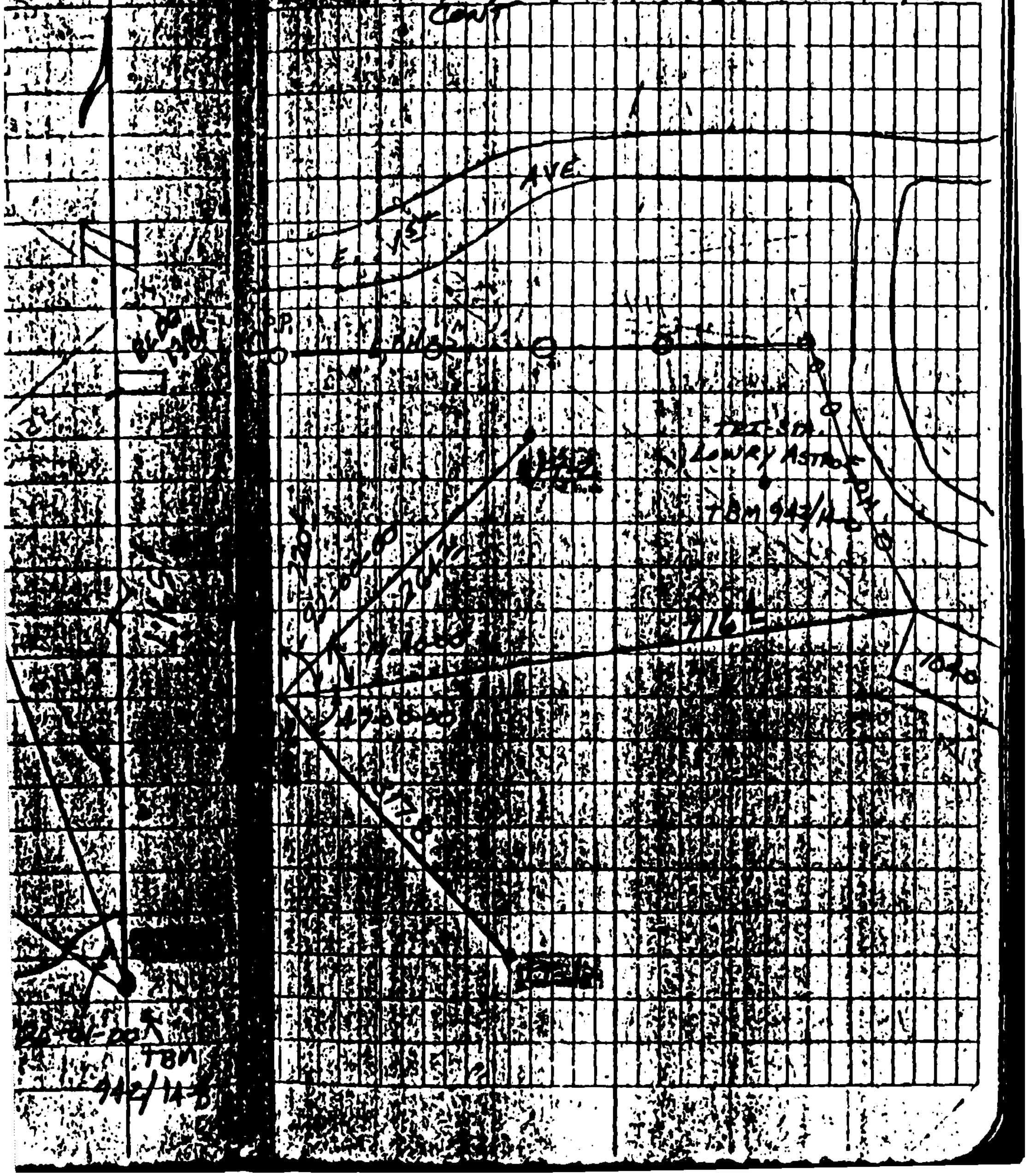
WELL LOCATIONS

4/18/84
CONT

942/10



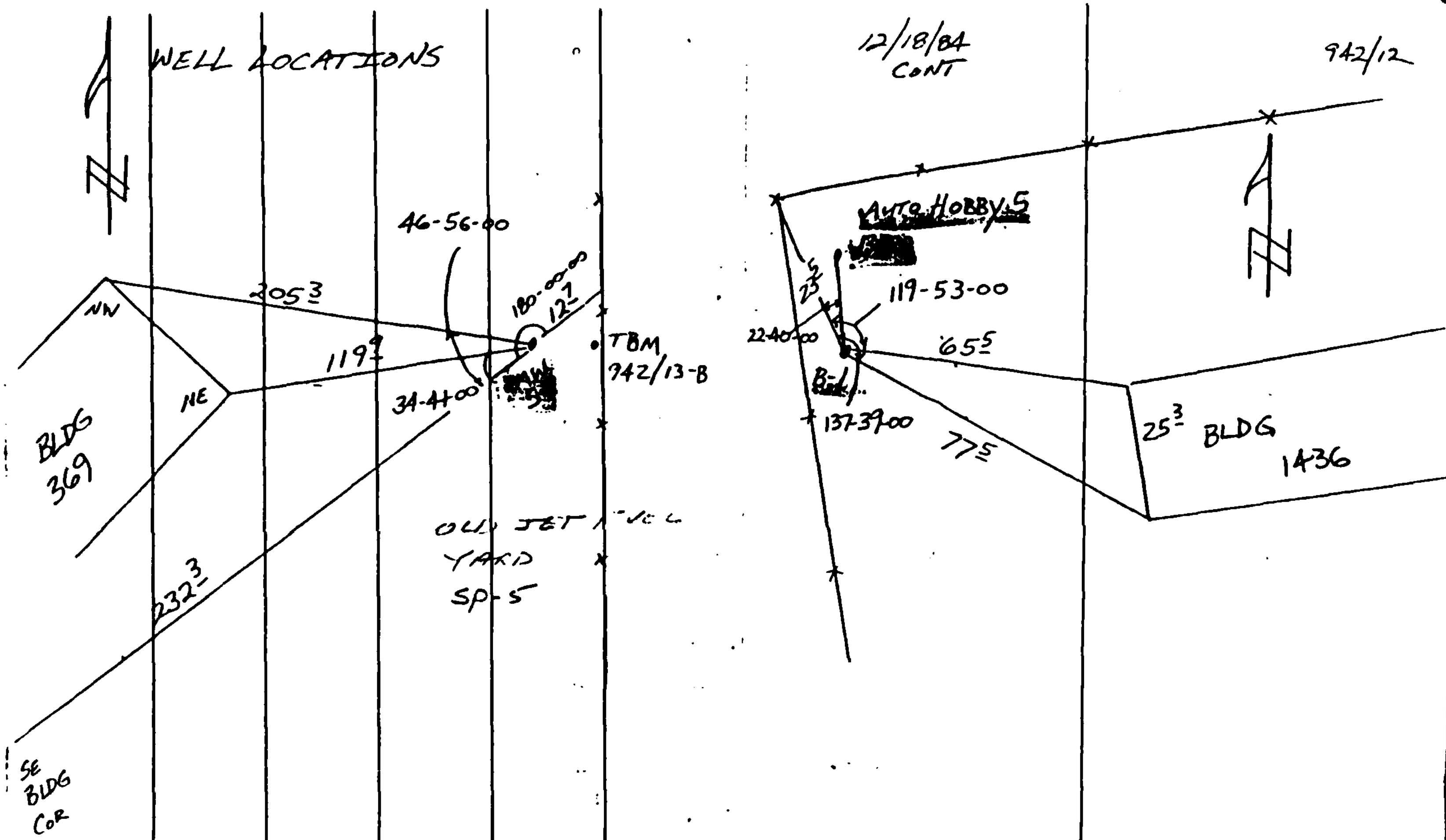
12/18/84 942/11
CONT



WELL LOCATIONS

12/18/84
CONT

942/12



LEVEL LOOPS TO WELL SITES

STA	BS	HI	FS	ELEV	
BM	5.20	394.25		5389.05	
TP 1			9.56	384.69	
⊼	5.73	390.42			
TBM 942/13-B			7.98	382.44	
⊼	11.72	394.16			
BM 942/13-A			5.11	389.05	389.05
BM 942/13-A	4.89	393.94		389.05	
TP 1			6.29	387.65	
⊼	6.76	394.41			
TP 2			5.72	388.69	
⊼	6.88	395.57			
TP 3			1.91	393.66	
⊼	10.17	403.83			
TP 4			3.55	400.28	
⊼	8.69	408.97			
TP 5			1.25	407.72	
⊼	6.89	414.61			
TBM 942/13-C			4.13	410.48	
	4.10	414.58			

12/9/84 ⊼ BURGETT
∅ BRANSON 942/13

TBM 942/13-A
BRASS CAP IN CONC. "5354" 1954
53± EAST OF NE COR BLDG 401, HANGAR #1
AND 1± SOUTH OF ASP. ℄

SET 1"x1"x12" HUB @ N-S FENCE
LINE, 12± EAST OF MW-5,
SEE Pg 12 FOR MW-5 LOCATION

SET 1"x1"x12" HUB @ NW COR. OF FENCE
ENCLOSURE, 55± SW'LY OF MW-1, SEE
Pg 10 FOR MW-1 LOCATION

2/12/91
Cont

STA	BS	HI	FS	ELEV
		414.58		
TP7			4.05	410.53
	7.16	417.69		
TBM 942/14-A			3.52	414.17
⊼	11.21	425.38		
TP9			1.84	423.54
⊼	9.88	433.42		
TBM 942/14-B			2.16	431.26
⊼	1.11	432.37		
TP11			11.26	421.11
⊼	2.11	423.22		
TP12			11.77	411.45
⊼	5.81	417.26		
TP13			6.63	410.63
⊼	7.17	417.80		
TP14			0.63	417.17
⊼	11.40	428.57		
TP15			0.57	428.00
⊼	11.91	439.91		
TP16			0.40	439.51
⊼	8.47	447.98		
TBM 942/14-C			0.21	447.77
⊼	0.24	448.01		

SET 1"x1"x12" HUB 5' SOUTH OF MW-2, SEE Pg 10 FOR MW-2 LOCATION

SET 1"x1"x12" HUB 5' SE'LY OF MW-3, SEE Pg 11 FOR MW-3 LOCATION

FD. STANDARD USC&GS BRASS CAP IN CONC. "LOWRY ASTRO" 1945, LOCATED 112' NW'LY FROM NW COR. BLDG 1040 AND 51± SW'LY FROM POWER POLE, SEE Pg 11

12/19/84
CONT

942/15

STA	BS	HI	FS	ELEV	
		448.01			
TP18			11.15	436.86	
⊼	0.80	437.66			
TP19			11.54	426.12	
⊼	0.34	426.46			
TP20			11.89	414.57	
⊼	0.30	414.87			
TP21			11.84	403.03	
⊼	0.19	403.22			
TP22			10.09	393.13	
⊼	3.13	396.26			
TP23			7.94	388.32	
⊼	5.00	393.32			
TP24			4.81	388.51	
⊼	4.60	393.11			
TP25			4.08	389.03	
⊼	1.67	390.70			
TP26			5.37	385.33	
⊼	3.80	389.13			
TP27			3.78	385.35	
⊼	7.65	393.00			
BM 942-13-A			3.93	389.07	5389.05

GROUND ELEVATIONS @ AUTO HOBBY S

12/19/84 CONT

942/16

STA	BS	HI	FS	ELEV			
BM 942	1.42	390.47		5389.05			
TP1 13-A			9.45	381.02			
⊼	3.31	384.33					
TP2			6.76	377.57			
⊼	4.40	381.99					
B-2			11.1	370.9		GRD. SEE Pg 12	FOR LOCATIONS
B-1			10.4	371.6		GRD.	
TP3			5.09	376.90			
⊼	7.36	384.26					
TP4			3.22	381.04			
⊼	9.33	390.37					
BM 942/13-A			1.31	5389.06	5389.05		

TEST HOLE ELEVATIONS

STA	BS	HI	FS	ELEV		
TBM 942/13-B	5.04	87.48		5382.44		
MW-5			5.27	82.21		GRD @ MW-5
M-W-5			3.26	84.22		TOP OF PVC
⊼	3.23	87.45				
TBM 942/13-B			5.00	82.45	5382.44	
TBM 942/12-C	4.94	15.42		410.48		
MW-1			4.80	10.62		GRD @ MW-1
MW-1			2.89	12.53		TOP OF PVC
⊼	2.90	15.43				
TBM 942/13-C			4.94	10.49	410.48	
TBM 942/14-A	4.98	19.15		414.17		
MW-2			4.86	14.29		GRD @ MW-2
MW-2			3.17	15.98		TOP OF PVC
⊼	3.22	19.20				
TBM 942/14-A			5.03	5414.17	5414.17	

12/20/84 E??GETT
JACKSON
HUGDAHL

?4?/1?

12/10/84 CONT

942/18

STA	BS	HI	FS	ELEV	
TBM 942/14-B	4.47	35.73		431.26	
MW-3			4.49	31.24	GRD @ MW-3
MW-3			3.49	32.24	TOP OF PVC
T	3.67	35.91			
TBM 942/14-B			4.66	31.25	
TBM 942/14-C	1.23	49.00		5447.77	
FT-1			11.8	37.2	GRD
FT-1			9.5	39.5	GRD
MW-4			14.16	34.84	GRD
MW-4			12.52	36.48	TOP OF PVC
	12.48	48.96			
TBM 942/14-C			1.19	47.77	

FIELD MEMORANDUM

ACTION	INFO	
To:	QHL	File: 01 016 2-17
		X-Ref:
		Date: 11/5/84

From: J. Werner

Reply Required By:

Subject: Lowry AFB - IRP project water well data

Reference(s):

Location and #	Depth from Ground level	PH	temp	Cond	Volume bailed
Site 2 MW1	3.1'	7.3	12.0 C	2016 1600 µHms	30 gals
Site 2 MW2	3.2'	7.2	12.0°C	1638 1300 µHms	30 gal
Site 2 MW3	10.4'	7.2	12.0°C	2016 1600 µHms	25 gal
SP1 (MW-5)	19.6'	7.2	14.0°C	1952 1600 µHms	25 g
Site 1 FT1 (MW-4)	17.6	6.9	12.0°C	6930 5500 µHms	20 gal

$$C_{field}[1 + .02(25 - T)] = C_{25°C}$$

ROUTING

114.8 (REV. 5-68)

Dames & Moore

APPENDIX E

FIELD AND LABORATORY QUALITY CONTROL PROGRAMS

FIELD AND LABORATORY QUALITY CONTROL PROGRAMS

FIELD INVESTIGATION QUALITY CONTROL PROGRAM

Quality control of field activities consists of following established procedures during the conduct of the work. In those cases that require the drilling of test borings, installation of piezometers or monitor wells, and taking of soil and water samples, the procedures include the preparation of records to document the compliance with these procedures. These field records include boring logs, monitor well installation records, daily field memoranda, sample shipment and test instruction forms for soil sample testing, and chain-of-custody records for all soil and water samples intended for chemical analyses. The nature of water sample tests was established in advance so that plans could be made to ship samples in an appropriate and timely manner.

The pH and specific conductivity meters used for field water quality measurements were calibrated with known standards immediately before the measurements were made. The HNU photoionization detector and explosimeter used to monitor vapors generated while drilling have internal calibration routines that were followed when the meters were turned on. A detailed description of sampling procedures is located in Section III.

LABORATORY QUALITY CONTROL PROGRAM

UBTL is an accredited laboratory of the American Industrial Hygiene (AIHA) Association (No. 17) and, as such, participates in an extensive interlaboratory proficiency analytical testing program sponsored by the National Institute for Occupational Safety and Health (NIOSH). In addition, UBTL is currently licensed by the Center for Disease Control (CDC) to perform chemical and clinical analyses of biological specimens and is State of Utah/USEPA approved for environmental analyses. The comprehensive internal quality control program at UBTL is detailed as follows.

Introduction

UBTL has implemented an effective system for Quality Control (QC). Procedures that are employed include:

1. Services of a full-time Quality Control/Quality Assurance Section;
2. Preparation of internal quality control samples;
3. Collection and evaluation of quality control data;
4. Generation of quality control charts; and
5. Instrument calibration and maintenance.

Sample Analyses

At least one blank sample and one reagent blank are included with each set of analyses and processed through the complete analytical procedure in order to detect any contamination in either collection media or reagents. In addition, duplicate analyses are accomplished on a minimum of 10 percent of all samples submitted from the field. Internal quality control samples, generated in the laboratory and containing known quantities of specified analyte(s), are run at the rate of 10 percent of the total field sample workload. At the completion of the analysis of a sample set, each chemist calculates his results and reports the results on the Analytical Report Form. Results for replicated samples and internal quality control samples are reported on the computer-generated Quality Control Data Sheet. Before the results are submitted to the Group Leader, another peer chemist analyst is assigned to check results for possible errors in the calculations. He must approve results reported on both the quality control sheet and the sample sheet. The Group Leader, after his evaluation of the data, gives the report sheets to the Quality Assurance Specialist (QAS) for his evaluation and implementation of any required action.

Specific steps are followed when any one QC sample result is determined to be out of control in connection with the analysis of a field sample set. QC charts with adjusted control limits of $\pm$ 3 standard deviations will generally be used to determine whether a result is out of control. If QC results are in control, the QAS signs off the report. It is then reviewed by the Section Head for accuracy of the results. Upon final approval of the reports by the QAS and the Section Head, the reports are sent to the sponsor.

The paperwork containing the raw data for a sample set (i.e., chart paper, computer readouts, paper tapes, calibration curves, tables of data, etc.) is collected and placed in an 8½-inch by 11-inch envelope that has been labeled with sample numbers, analyst, date, and other pertinent information. The envelopes are filed by laboratory number for possible future reference and data retrieval. Raw data for each sample analysis are therefore readily available, if needed.

Quality Control Sample Data Analysis

A record of the preparation of internal QC samples is detailed in the QC log book maintained by the QAS. As appropriate, a set of QC samples is distributed to the chemist along with each sample set at an average rate of at least 10 percent of the submitted samples. The analyses and data evaluations are performed for these QC samples, along with the submitted samples, and results are tabulated on the computer-generated Quality Control Data Sheet. At least duplicate results are reported for each internal QC sample.

QC charts are generated for each analyte through the analysis of QC sample results. Each result is divided by the theoretical value to standardize results so that data from all concentrations can be directly compared for accuracy and precision. When a control data set of N sample results has been accumulated, the following statistics are calculated: mean percent recovery, replicate standard deviation, and set standard deviation. These statistics are then used to determine accuracy and precision QC limits.

The control data set is updated after evaluation of 20 successive QC samples and includes data on the 50 most recent results. Any control sample analysis that is beyond accuracy or precision limits is not used in the subsequent determination of new limits.

External Quality Control Programs

In addition to internally generated QC data, other information concerning QC is provided by the participation of UBTL in four interlaboratory QC programs: NIOSH Proficiency Analytical Testing (PAT) Program; two CDC Blood Lead QC Programs; and State of Utah Environmental Quality Control Program. The PAT Program and the CDC Blood Lead Programs involve the participation of more than 100 laboratories on a nationwide basis. The PAT Program addresses the analysis of filter samples for lead, cadmium, zinc, free silica, and asbestos and the analysis of charcoal tubes for various organic solvents.

Laboratory Data Reduction

A significant fraction of the Chemistry Department's work involves data processing. Mathematical models, based upon analysis of standard solutions or samples, are generated in order to determine the quantity of analyte present in the samples. Considerable time and effort are saved by the utilization of automated data processing procedures. Data processing by the computer can include, for example, calculations, generation of standard calibration curves, mathematical modeling of standard curves, statistical analyses, and the generation of hard copy output. Advantages intrinsic to the use of an automated system include more accurate calculations, immediate and accurate generation of data plots, fewer transcription errors, and no calculation errors after programs have been verified and documented. In general, the types of data that are processed are those derived from the following techniques: atomic absorption and flame emission spectroscopy, gas and liquid chromatography, optical absorbance spectrophotometry, specific ion electrode, fluorescence spectroscopy, and wet chemistry determinations. Similar functions are employed for QC data. In addition, the data system is utilized to store QC data, provide statistical analyses, and generate and update QC charts.

The advantage of the provision for statistical analyses and the production of QC charts by automation is that the charts may be easily updated with minimal effort. QC data and any required action may, therefore, be provided on a daily basis.

Reporting Procedures

The analytical data are reported to the sponsor at the completion of each sample set. The report includes the following items:

1. A memorandum describing the sample set; the condition and appearance (i.e., homogeneity, integrity, etc.) of the samples upon receipt at UBTL; the method, equipment, and technique used in the determination; any interferences that were observed; and any unusual circumstances that may have occurred during the analysis. [The limit(s) of detection are also reported.]

2. UBTL Analytical Report Form, including field ID number, laboratory ID number, identification of the analytes, results of each determination, limit(s) of detection, and comments.

3. Other items, such as copies of strip chart recorder output, computer printout sheets, and other raw data (to be included as required).

Instrumentation

Each major equipment item at the UBTL Chemistry Department undergoes a routine preventive maintenance check on a regular schedule. This check is accomplished by a trained engineer. In addition, performance checks are made by the analyst prior to the analysis of each set of samples. This involves the analysis of one or more standards and a comparison of the values obtained with previous results and conditions. This information is recorded in an instrumentation log.

When an instrument or apparatus malfunctions and the problem is not readily corrected, the appropriate Section Head is notified. If it is determined that a visit by the service representative is required, a service call is scheduled and the QAS is notified. Action by the service representative is recorded by the QAS in the Instrument Maintenance Log, and the appropriate customer field and service order forms are filed, by instrument, in the Instrument Maintenance Log Supplement File. In an effort to monitor and maintain instrument specifications, logs for each of the AA spectrophotometers, the gas chromatographs (GC), the X-ray diffractometer (X-ray), and the mass spectrometers (MS) have been provided for the analytical chemists' use each time an analysis is performed. The AA instrumentation logs contain entries for date, analyst, lamp number (if more than one lamp is available), standard concentration (recommended in manual), reading in milliabsorbence units, and a column for when instrumental parameters differ from the recommended conditions listed in the manual. The GC, X-ray, and MS logs contain entries for date, time, analyst, set identification number, and comments on parameters or performance.

Training

UBTL has established a continuing program of training of current personnel with respect to QC procedures. In addition, an intensive program for the training of recently recruited personnel in both analytical methods and techniques and QC policies has been implemented. It is the responsibility of the QAS and the Laboratory Director to train all laboratory personnel.

Results of the Laboratory QC Program

The results of the QC analyses for soil and ground water samples are presented in Appendix G, Chemical Analysis Data.

Soil Analyses

The laboratory QC program for soils, presented in Appendix G, included two spiked and two duplicate samples for PCBs, aldrin, dieldrin, endrin, lindane, and p,p'-DDT. Recoveries of the spikes were good, ranging between 78.4 and 132 percent and averaging 107.7 percent. Duplicate analyses for these parameters were also acceptable, with initial, first and second analyses all being less than the limit of detection. Other parameters analyzed in duplicate included TOX, oil and grease, moisture content, o,p-DDT, DDD, and DDE. The precision of these analyses was also acceptable. The only spike recovery that was not acceptable was that for TOX. Only 45.3 percent of a spike concentration of 187 µg/g was recovered. The low recovery was checked by reanalysis and confirmed. A matrix effect is suspected.

Ground Water Analyses

The laboratory QC program for ground water samples, presented in Appendix G, included analyses of 12 duplicates and 7 spiked samples. All of the duplicate sample analyses are acceptable. The spike recoveries were generally acceptable, with three exceptions. The TOC recovery was high at 169 percent; however, the initial TOC value was near the detection limit. Consequently, the reported values of TOC may be slightly overestimated. The TOX recovery, 36.8 percent of a 100 µg/L spike concentration, is unacceptably low, and an interference effect is suspected.

The matrix effect was attributed to the presence of sulfates and chlorides in the ground water masking the detection of lead during analysis. To confirm the matrix effect, an additional analysis on ground water from MW-1 was performed during October 1985. By applying the method of standard additions, a result of 0.1 mg/L for lead was obtained.

The laboratory report and the curve used to determine the concentrations for this sample are presented in Appendix G, Analytical Data.

Two lead spike concentrations of 0.0476 and 0.476 mg/L had recoveries of 19 and 13.3 percent, respectively. The low recovery was checked by reanalysis and confirmed. A matrix effect is suspected. Because of this low recovery, the initial lead values (i.e., below the limit of detection) are suspect.

APPENDIX F

CHAIN-OF-CUSTODY FORMS

UBTL

DAMES & MOORE CHAIN-OF-CUSTODY RECORD

Sample Source & Client: LOWRY AFB USAF

Project Title: IRP II

Job No. 01016-217

Field Personnel (Signature)

Date	Time	Sample I.D. No.	Sample Type	No. of Containers	Sampling Site	Remarks
10-11	2:50PM	GS-84-0219	SOIL	1	AUTO HOBBY B-1	HNU = 0
		0220	SOIL	1		HNU = 0
		0221	SOIL	1		
		0222	SOIL	1		HNU = 0
		0223	"	1		
		0224	"	1	AUTO HOBBY B-2	HNU = 0
		0225	"	1		HNU = 0
		0226	"	1		
		0227	"	1		
		0228	"	1		
		0229	"	1		

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
	10-12	3:00								10/15/84	3:10PM
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time

4BTL

DAMES & MOORE CHAIN-OF-CUSTODY RECORD

Sample Source & Client: Lowry AFB, USAF

Project Title: IRP Phase II

Job No. 01016-212

Field Personnel (Signature): [signature]

Date	Time	Sample I.D. No.	Sample Type	No. of Containers	Sampling Site	Remarks
10/11	1510	GS-84-0230	Soil	1	FT2-B-X3 corrected	HNU = 0
11	11	-0231	11	11	11	HNU = 0
11	11	-0232	11	11	11	HNU = 0
11	11	-0233	11	11	11	HNU = 0
11	11	-0234	11	11	11	HNU = 0
11	11	-0235	11	11	11	HNU = 0
11	11	-0236	11	11	11	HNU = 0

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
[signature]	10/11	1515							[signature]	10/15/91	3:10 PM
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time

DAMES & MOORE CHAIN-OF-CUSTODY RECORD

Sample Source & Client: USAF Lowry

Project Title: IRP

Job No. 0016-217

Field Personnel (Signature): [signature]

Date	Time	Sample I.D. No.	Sample Type	No. of Containers	Sampling Site	Remarks
10/16	10:30	GS840247	SPT	1	FT-1	HNU - 0
"	"	GS840248	SPT	1	"	HNU - ~~[illegible]~~0
"	"	GS840249	SPT	1	"	HNU - 150
"	"	GS840250	SPT	1	"	HNU - 150
"	"	GS840251	SPT	1	"	HNU - 150
"	"	GS840252	SPT	1	"	HNU 0
"	"	GS840253	SPT	1	"	HNU 0

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
									[signature]	10/18/84	2:00 P.M.
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time

DAMES & MOORE CHAIN-OF-CUSTODY RECORD

Sample Source & Client: USAF - Lowry

Project Title: IRP

Job No. 0106 217

Field Personnel (Signature):

Date	Time	Sample I.D. No.	Sample Type	No. of Containers	Sampling Site	Remarks
10/18	1200	#1	Soil	1	MW4	HNU = 0
〃	〃	#2	〃	〃	〃	HNU = 0
		#3	〃	〃		HNU = 0
		#4	〃			HNU = 0
		#5	〃			HNU = 0
		#6				HNU = 0
		#7				HNU = 0
		#8				HNU = 0
		#9				HNU = 0
		#10				HNU = 0
		QA				HNU = 0

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
	10/19	1500							A B Torgeson	10/24/94	11:00 AM
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time

DAMES & MOORE CHAIN-OF-CUSTODY RECORD

Sample Source & Client						Field Personnel (Signature)
Project Title					Job No.	
Date	Time	Sample I.D. No.	Sample Type	No. of Containers	Sampling Site	Remarks
10/19	500	#1	Soil	1	MW5	HNU = 0
"	"	#2	"	"	"	HNU = 0
		#3				HNU = 0
		#4				HNU = 0
		#5				HNU = 0
		#6				HNU = 0
		#7				HNU = 0
		#8				no reading
		#9				HNU = 0
		#10				HNU = 0
		#11				HNU = 0

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
	10/19	500								10/22/94	11:00 am
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time

CHAIN-OF-CUSTODY RECORD

SAMPLER'S NAME: B. Werner SAMPLING LOCATION: Lowry AFB

COMPANY: DAmes + Moore TYPE OF SAMPLES: WAter

MONITOR WELL NUMBER	DATE	TIME	NUMBER OF CONTAINERS	CONTAINER IDENTIFICATION NUMBER
Site 2 mw3	11/5	1800	1	GN-840-339
				337
				335
				333
				331
				329
~~SPT~~ OK ~~Site~~ EFI				359
				358
				357
				356

DATE	TIME	RELINQUISHED BY (SIGNATURE)	RECEIVED BY (SIGNATURE)
11/5	1800	[signature]	
11/6/84	10:00 Am		[signature]

METHOD OF SHIPMENT	DISPATCHED BY (SIGNATURE)
FED EXP.	
RECEIVED AT ANALYTICAL LABORATORY BY (SIGNATURE) → → →	[signature]

*One copy of this form should be kept on file at the plant. The other should accompany the samples to the laboratory. Each time the samples pass from the possession of one person to another, this form should be signed in the appropriate spaces.

CHAIN-OF-CUSTODY RECORD

SAMPLER'S NAME: S. Werner SAMPLING LOCATION: Lowry

COMPANY: Dames & Moore TYPE OF SAMPLES: Water

MONITOR WELL NUMBER	DATE	TIME	NUMBER OF CONTAINERS	CONTAINER IDENTIFICATION NUMBER
Site 2 MW1	11/5	1800	1	GN-840-296
				-297
				298
				299
				301
				302
				303
				316
				304
				306

DATE	TIME	RELINQUISHED BY (SIGNATURE)	RECEIVED BY (SIGNATURE)
11/5	1800	S. Werner	S
11/6/84	10.00Am		[illegible signature]

METHOD OF SHIPMENT	DISPATCHED BY (SIGNATURE)
FED. EXP.	

RECEIVED AT ANALYTICAL LABORATORY BY (SIGNATURE) → → →	[illegible signature]

*One copy of this form should be kept on file at the plant. The other should accompany the samples to the laboratory. Each time the samples pass from the possession of one person to another, this form should be signed in the appropriate spaces.

CHAIN-OF-CUSTODY RECORD

SAMPLER'S NAME: Schwerner **SAMPLING LOCATION:** Lowry AFB

COMPANY: Dames + Moore **TYPE OF SAMPLES:** Water

MONITOR WELL NUMBER	DATE	TIME	NUMBER OF CONTAINERS	CONTAINER IDENTIFICATION NUMBER
SPI site	11/5	1800	1	GN-840-354
				353
				352
				351
				344
				343
				342
				341
site 1 ETI				365
				363

DATE	TIME	RELINQUISHED BY (SIGNATURE)	RECEIVED BY (SIGNATURE)
11/5/84		[signature]	
11/6/84	10:00 AM		[signature]

METHOD OF SHIPMENT	DISPATCHED BY (SIGNATURE)
RECEIVED AT ANALYTICAL LABORATORY BY (SIGNATURE) → → →	[signature]

*One copy of this form should be kept on file at the plant. The other should accompany the samples to the laboratory. Each time the samples pass from the possession of one person to another, this form should be signed in the appropriate spaces.

CHAIN-OF-CUSTODY RECORD

SAMPLER'S NAME: S. Weimer SAMPLING LOCATION: Lowry AFB

COMPANY: Dames + Moore TYPE OF SAMPLES: Water + Soil

MONITOR WELL NUMBER	DATE	TIME	NUMBER OF CONTAINERS	CONTAINER IDENTIFICATION NUMBER
	11/7	1300	Water 6 - Phenol	Site 2 MW3 (1 sample) MW1 (4 samples) MW2 (1 sample)
	11/7		MW4 2 B-1	Drum Sample test for EP toxicity
			auto hobby shop	and ignitability

DATE	TIME	RELINQUISHED BY (SIGNATURE)	RECEIVED BY (SIGNATURE)
11/7	1600	S. W. [signature]	
11/8/84	10:00 Am		AB Torgensen

METHOD OF SHIPMENT	DISPATCHED BY (SIGNATURE)
FED. EXP.	
RECEIVED AT ANALYTICAL LABORATORY BY (SIGNATURE) → → →	AB Torgensen

*One copy of this form should be kept on file at the plant. The other should accompany the samples to the laboratory. Each time the samples pass from the possession of one person to another, this form should be signed in the appropriate spaces.

CHAIN-OF-CUSTODY RECORD

SAMPLER'S NAME: S. Werner SAMPLING LOCATION: Lowry AFB

COMPANY: Dames + Moore TYPE OF SAMPLES: Water

MONITOR WELL NUMBER	DATE	TIME	NUMBER OF CONTAINERS	CONTAINER IDENTIFICATION NUMBER
Site 1 FT 1	11/5	1800	1	GN-840-361
				349
				348
				347
				346

DATE	TIME	RELINQUISHED BY (SIGNATURE)	RECEIVED BY (SIGNATURE)
11/5/84		[signature]	
11/6/84	10:00 AM		[signature]

METHOD OF SHIPMENT	DISPATCHED BY (SIGNATURE)

RECEIVED AT ANALYTICAL LABORATORY BY (SIGNATURE) → → → [signature]

*One copy of this form should be kept on file at the plant. The other should accompany the samples to the laboratory. Each time the samples pass from the possession of one person to another, this form should be signed in the appropriate spaces.

CHAIN-OF-CUSTODY RECORD

SAMPLER'S NAME: S. Werner **SAMPLING LOCATION:** Lowry AFB

COMPANY: Dames + Moore **TYPE OF SAMPLES:** Water

MONITOR WELL NUMBER	DATE	TIME	NUMBER OF CONTAINERS	CONTAINER IDENTIFICATION NUMBER
site 2 mw1	11/5	1800	1	GN-840-307
				308
				309
				311
				314
site 2 mw2				317
				319
				321
				323
				325
				327

DATE	TIME	RELINQUISHED BY (SIGNATURE)	RECEIVED BY (SIGNATURE)
11/5/84		[signature]	
11/6/84	10:00 AM		[signature]

METHOD OF SHIPMENT	DISPATCHED BY (SIGNATURE)
RECEIVED AT ANALYTICAL LABORATORY BY (SIGNATURE) → → →	[signature]

*One copy of this form should be kept on file at the plant. The other should accompany the samples to the laboratory. Each time the samples pass from the possession of one person to another, this form should be signed in the appropriate spaces.

APPENDIX G

ANALYTICAL DATA

UBTL ANALYTICAL REPORT

Lowry AFB - Soil Analyses (1)

				Area 1, Fire Training Zone					
Parameter	Method	Units	Detection Limit	FT2-B-3#2 2.5'-4'	FT2-B-3#3 5'-6.5'	FT2-B-3#4 7.5'-9'	FT2-B-3#6 15'-16.5'	B-4#2 2.5'-4'	B-4#3 5'-6.5'
Lead	239.1 (2)	μg/g	10	31	30	27	26	30	38
% Moisture	160.3 (2)	%	1.	16.	19.	17.	20.	22.	22.
Oil & Grease	413.2 (2)	mg/g	.007	*	0.035	*	*	0.13	0.023
TOC	415.1 (2)	μg/g	5.	2200.	2000.	5700.	190.	1800.	1500.
TOX	9020 (3)	μg/g	5.	*	*	*	*	*	*

See Soil Q.C. report for footnotes.

UBTL ANALYTICAL REPORT
Lowry AFB - Soil Analyses (1)

Parameter	Method	Units	Detection Limit	Area 1, Fire Training Zone B-4#4 7.5-9'	B-4#5 10-11.5'	MW-4#2 2.5-4'	MW-4#4 7.5-9'	MW-4#6 15-16.5'	MW-4#10 30-36.5'
Lead	239.2 (2)	µg/g	10	30	23	28	28	27	27
% Moisture	160.3 (2)	%	1.	18.	20.	12.	25	24.	30.
Oil & Grease	413.2 (2)	mg/g	.007	0.045	0.029	0.011	0.032	0.020	0.016
TOC	415.1 (2)	µg/g	5.	290	150	1700	470	460	250
TOX	9020 (3)	µg/L	5.	*	*	*	*	*	*

See Soil Q.C. report for footnotes.

UBTL ANALYTICAL REPORT
Lowry AFB - Soil Analyses (1)

				Area 3, Old Jet Fuel Yard: Site SP-1			
Parameter	Method	Units	Detection Limit	MW-5#3 5'-6.5'	MW-5#5 7.5'-9'	MW-5#6 10'-11.5'	MW-5#8 20'-21.5'
% Moisture	160.3 (2)	%	1.	13.	12.	13.	1.
Oil & Grease	413.2 (2)	mg/g	.007	0.029	0.020	0.029	0.027
TOC	415.1 (2)	μg/g	5.	1300.	1500.	1700.	150.
TOX	9020 (3)	μg/g	5.	*	*	*	*

See Soil Q.C. report for footnotes.

UBTL ANALYTICAL REPORT
Lowry AFB - Soil Analyses (1)

				Area 4, Auto Hobby Shop: Site S-5					
Parameter	Method	Units	Detection Limit	S-5-B-1#1 0-1.5'	S-5-B-1#2 1.5-3'	S-5-B-1#5 10-11.5'	S-5-B-2#1 0-1.5'	S-5-B-2#2 2.5-4'	S-5-B-2#5 10-11.5'
Lead	239.2 (1)	µg/g	10	160.	36.	22.	51.	26.	32.
% Moisture	160.3 (2)	%	1.	9.	11.	15.	4.	6.	16.
Oil & Grease	413.2 (2)	mg/g	0.007	5.7	0.16	*	0.91	0.11	*
TOC	415.1 (2)	µg/g	5.	4600.	3900.	1300.	6300.	3200.	1400.
TOX	9020 (3)	µg/g	5.	*	*	*	*	*	*

See Soil Q.C. report for footnotes.

UBTL ANALYTICAL REPORT
Lowry AFB - Soil Analyses (1)

Parameter	Method	Units	Detection Limit	EP Toxicity and Ignitability: Drum MW 4	Drum B-1	Drum Auto Hobby Shop
Ignitability	1010 (6)			NI	NI	NI
Arsenic	206.2 (2)(7)	mg/L	0.01	*	*	*
Barium	208.1 (2)(7)	mg/L	0.1	0.9	4.1	0.1
Cadmium	213.1 (2)(7)	mg/L	0.01	*	*	*
Chromium	218.1 (2)(7)	mg/L	0.05	*	*	*
Lead	239.2 (2)(7)	mg/L	0.01	*	*	*
Mercury	245.1 (2)(7)	mg/L	0.0002	*	*	*
Selenium	270.2 (2)(7)	mg/L	0.01	*	*	*
Silver	272.1 (2)(7)	mg/L	0.01	*	*	*
Endrin	608 (4)	µg/L	0.02	*	*	*
Lindane	608 (4)	µg/L	0.01	*	*	*
Methoxychlor	608 (4)	µg/L	0.1	*	*	*
Toxaphene	608 (4)	µg/L	1.0	*	*	*
2,4-D	509B (5)	µg/L	0.05	*	*	*
2,4,5 TD (Silvex)	509B (5)	µg/L	0.05	*	*	*

See Soil Q.C. report for footnotes.

UBTL QUALITY CONTROL REPORT
Lowry AFB - Soil Analyses (1)

Parameter	Method	Units	Detection Limit	Spiked Sample	Initial Value	Spike Conc.	Percent Recovered	Split Sample	First Value	Second Value	Method Blank
Arsenic	206.2 (2)(7)	mg/L	0.01	Drum B-1	*	0.0476	107.3	Drum B-1	*	*	*
Barium	208.1 (2)(7)	mg/L	0.1	Drum B-1	4.090	2.439	55.8 (8)	Drum B-1	4.147	4.033	*
Cadmium	213.1 (2)(7)	mg/L	0.01	Drum B-1	*	.0952	94.7	Drum B-1	*	*	*
Chromium	218.1 (2)(7)	mg/L	0.05	Drum B-1	*	.286	112.5	Drum B-1	*	*	*
Lead	2302 (2)(7)	mg/L	0.01	Drum B-1	*	0.0476	88.1	Drum B-1	*	*	*
Mercury	245.1 (2)(7)	mg/L	0.2	Drum B-1	*	0.9901	98.2	Drum B-1	*	*	*
Selenium	270.2 (2)(7)	mg/L	0.01	Drum B-1	*	0.0476	109.2	Drum B-1	*	*	*
Silver	272.1 (2)(7)	mg/L	0.01	Drum B-1	*	.0952	88.6	Drum B-1	.012	*	*
% Moisture	160.3 (2)	%	1.					Site S-5 S-5-B-1#1 0-1.5'	9.	10.2	*
Oil & Grease	413.2 (2)	mg/g	0.007	S-5-B-1#1 0-1.5'	5.7	7.3	86.9	S-5-B-1#2 1.5'-3'	0.162	0.154	*
TOC	415.1 (2)	µg/g	5.	B-4#3 5'-6.5'	3.0	1.96	69.8	B-4#3 5-6.5'	1500	1600	*

See Soil Q.C. report for footnotes.

UBTL QUALITY CONTROL REPORT

Lowry AFB - Soil Analyses (1)

TOX	9020 (3)	µg/g	5.	S-5-B-1#1 0-1.5'	*	42.	87.	S-5-B-1#1 0-1.5'	*	*	*
Endrin	608 (4)(7)	µg/L	0.02	Drum B-1	*	.05	96	Drum B-1	*	*	*
Lindane	608 (4)(7)	µg/L	0.01	Drum B-1	*	.05	96	Drum B-1	*	*	*
Methoxychlor	608 (4)(7)	µg/L	0.1	Drum B-1	*	0.5	82	Drum B-1	*	*	*
Toxaphene	608 (4)(7)	µg/L	0.1	Drum B-1	*	0.5	82.	Drum B-1	*	*	*
2,4,-D	509B (5)(7)	µg/L	0.05	Drum B-1	*	2.5	124	Drum B-1	*	*	*
2,4,5-TP (Silves	509B (5)(7)	µg/L	0.05	Drum B-1	*	2.5	64	Drum B-1	*	*	*

See next page for footnotes.

UBTL Quality Control Report
Lowry AFB - Soil Analysis (1)

(1) Results not corrected for recent moisture.
(2) Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, revised in March 1983, modified for use with soil.
(3) Test methods for Evaluating Solid Waste, SW-846, 2nd ed., July 1982, modified for use on O.I. Comp. Model 610 TOX Analysis with soil.
(4) Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA 600/4-82-057, July 1982, modified for use with soil.
(5) Standard Methods for the Examination of Water and Wastewater, 16th ed. 1985, modified for use with soil samples.
(6) Test Methods for evaluating Solid Waste, SW-846, 2nd ed. July 1982.
(7) Sample has been extracted for EP Toxicity according to method No. 1310 published in E.P.A. Publication No. SW-846.
(8) The low recovery was checked by reanalysis and confirmed. A matrix effect is suspected.

Note: The analytical technique between the Methods published in EPA-SW-846, EPA 600/4-79-020, and Standard Methods 16th ed. are the same.

* Denotes Value less than the limit of detection.

NI Denotes the sample was not ignitable.

UBTL ANALYTICAL REPORT
Lowry AFB - Water Analyses

Parameter	Method	Units	Detection Limit	Area 1 Fire Training Zone FT-1 MW-4
Lead	239.2 (1)	mg/L	0.01	*
Oil & Grease	413.2 (1)	mg/L	0.5	1.6
TOC	415.1 (1)	mg/L	1.	20.
TOX	9020 (2)	µg/L	10	100.

See Water Q.C. report for footnotes.

UBTL ANALYTICAL REPORT
Lowry AFB - Water Analyses

Parameter	Method	Units	Detection Limit	Area 2, Sanitary Landfill Zone T-1, MW-1	D-2, MW-3	D-1, MW-2
Cadmium	213.1 (1)	mg/L	0.01	*	*	*
Chromium	218.1 (1)	mg/L	0.05	*	*	*
Lead	239.2 (1)	mg/L	0.01	*	*	*
Nickel	249.1 (1)	mg/L	0.05	*	*	*
Silver	272.1 (1)	mg/L	0.01	*	*	*
Oil & Grease	413.2 (1)	mg/L	0.5	2.5	1.4	3.6
Phenolics	420.2 (1)	mg/L	0.01	*	0.02	0.02
TOC	415.1 (1)	mg/L	1.	11.	6.4	20.
TOX	9020 (2)	µg/L	10.	74.	61.	93.
Aldrin	608 (3)	µg/L	0.01	*	*	*
Chlordane	608 (3)	µg/L	0.02	*	*	*
Dieldrin	608 (3)	µg/L	0.01	*	*	*
DDD	608 (3)	µg/L	0.02	*	*	*
DDE	608 (3)	µg/L	0.02	*	*	*
o,p-DDT	608 (3)	µg/L	0.05	*	*	*
p,p'-DDT	608 (3)	µg/L	0.05	*	*	*
Endrin	608 (3)	µg/L	0.02	*	*	*
Endrin Aldehyde	608 (3)	µg/L	0.02	*	*	*
Heptachlor	608 (3)	µg/L	0.01	*	*	*
Lindane	608 (3)	µg/L	0.01	*	*	*

See Water Q.C. report for footnotes.

UBTL ANALYTICAL REPORT
Lowry AFB - Water Analyses

Parameter	Method	Units	Detection Limit	Area 3 Site SP-1 Old Jet Fuel Yard MW-5
Oil & Grease	413.2 (1)	mg/L	0.5	6.6
TOC	415.1 (1)	mg/L	1.	5.7
TOX	9020 (2)	µg/L	10.	61.

See Water Q.C. report for footnotes.

UBTL QUALITY CONTROL REPORT
Lowry AFB - Water Analyses

Parameter	Method	Units	Detection Limit	Spiked Sample	Initial Value	Spike Conc.	Percent Recovered	Split Sample	First Value	Second Value	Method Blank
Cadmium	213.1 (1)	mg/L	0 01	Area 2 MW-1	*	.0476	101.1	Area 2 MW-1	*	*	*
Chromium	218.1 (1)	mg/L	0.05	Area 2 MW-1	*	0.2857	100.4	Area 2 MW-1	*	*	*
Lead	239.2 (1)	mg/L	0.01	Area 2 MW-1	*	0.4762	4.3 (5)	Area 2 MW-1	*	*	*
Nickel	249.1 (1)	mg/L	0.05	Area 2 MW-1	*	.4762	83.9	Area 2 MW-1	*	*	*
Silver	272.1 (1)	mg/L	0.01	Area 2 MW-1	*	.0952	82.1	Area 2 MW-1	*	*	*
Oil & Grease	413.2 (1)	mg/L	0.5	SP-1 MW-5	6.6	3.4	88.2	SP-1 MW-5	7.1	6.0	*
Phenolics	420.2 (1)	mg/L	10.	Area 2 MW-1	*	99	110	Area 2 MW-1	*	*	*
TOC	415.1 (1)	mg/L	1.	SP-1 MW-5	5.7	2.	104	SP-1 MW-5	5.80	5.74	*
TOX	9020 (2)	µg/L	10.	SP-1 MW-5	61.	19.	44 (5)	SP-1 MW-5	59.7	61.6	*
Aldrin	608 (3)	µg/L	0.01	Area 2 MW-1	*	.20	105	Area 2 MW-1	*	*	*
Dieldrin	608 (3)	µG/L	0.01	Area 2 MW-1	*	0.50	140	Area 2 MW-1	*	*	*
p,p-DDT	608 (3)	µg/L	0.05	Area 2 MW-1	*	0.5	240 (6)	Area 2 MW-1	*	*	*
Endrin	608 (3)	µg/L	0.02	Area 2 MW-1	*	0.50	170	Area 2 MW-1	*	*	*
Heptachlor	608 (3)	µg/L	0.01	Area 2 MW-1	*	0.2	115	Area 2 MW-1	*	*	*
Lindane	608 (3)	µg/L	0.01	Area 2 MW-1	*	0.2	110	Area 2 MW-1	*	*	*

See next page for footnotes.

UBTL Quality Control Report
Lowry AFB - Water Analysis

(1) Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, revised March 1983.

(2) Test Methods for Evaluating Solid Waste, SW-846, 2nd ed. July 1982, modified for use on O.I. Comp. Model 610 TOX Analyses.

(3) Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA 600/4-82-057, July 1982.

(4) Standard Methods for the Examination of Water and Wastewater, 16th ed. 1985.

(5) The low recovery was checked by analysis and confirmed. A matrix effect is suspected.

(6) p,p-DDT decomposes on column, therefore the possibility of unusual results are inherent.

(7) Recoveries are high because of a spiking solution that had been concentrated due to being left with the cap off over-night. This was confirmed by analysis of the spiking solution.

Note: The analytical technique between the Methods published in EPA-SW-846, EPA-600/4-79-020, and Standard Methods 16th ed. are the same.

* Denotes Value less than the limit of detection.

UBTL, INC.
520 WAKARA WAY • SALT LAKE CITY, UTAH 84108 • 801 / 584-3232

October 31, 1985
Refer to: 85C457

DAMES & MOORE
NOV 4 1985
Park Ridge, Illinois

Dr. Kenneth J. Stimpfl
Dames & Moore
1550 Northwest Hwy
Park Ridge, IL 60068

Dear Dr. Stimpfl:

Sample number MW-1 from Lowery AFB was resampled and reanalyzed for Lead by request from the Air Force. The sample was analyzed by Atomic Absorption Spectroscopy using a Perkin-Elmer 5000 Spectrophotometer equipped with an HGA 500 graphite furnace at a wavelength of 283.3 nm.

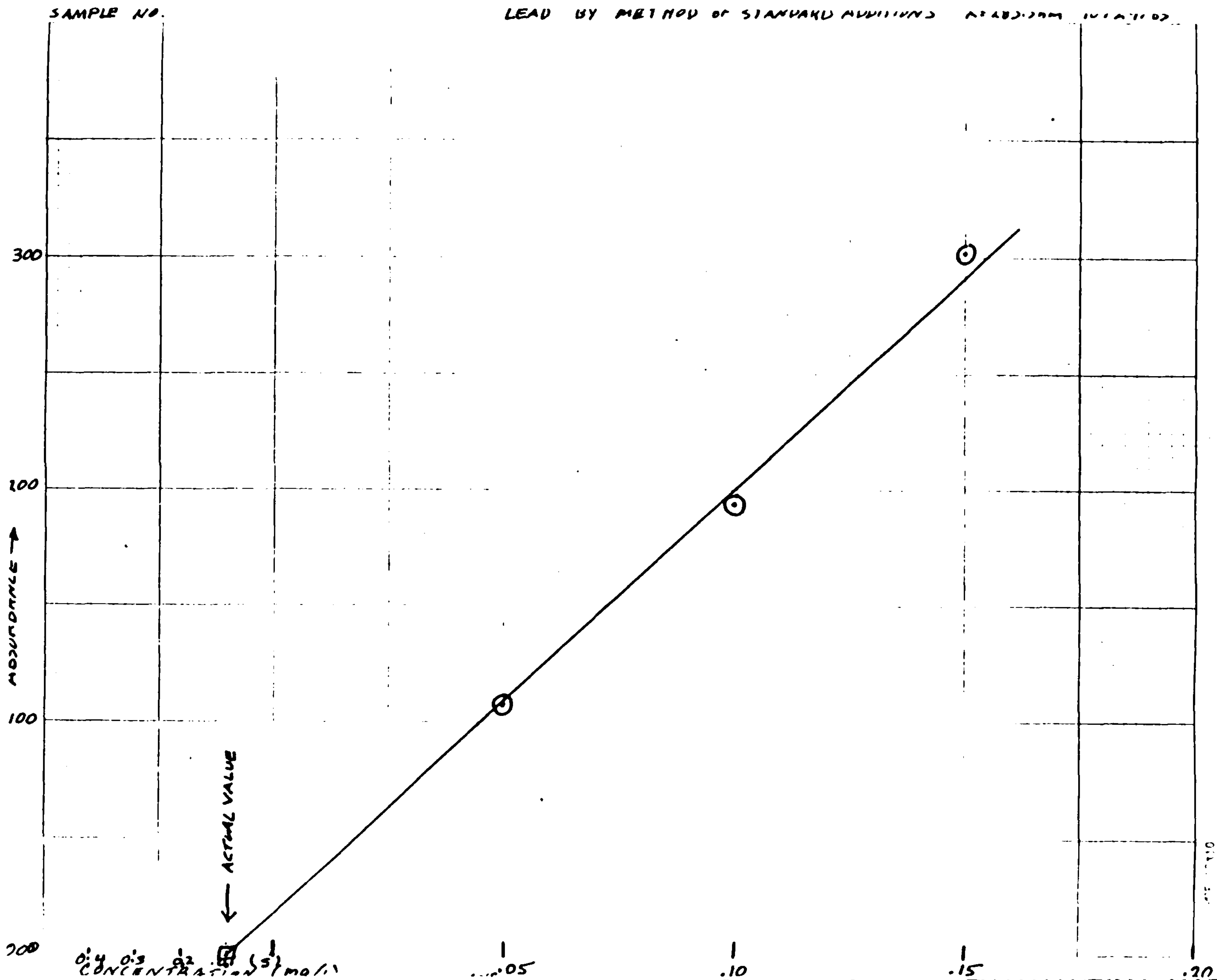
The solution was first analyzed without dilution resulting in a result of less than the limit of detection (0.01 mg/L) and a negligible spike recovery. This indicated the presence of severe negative matrix interferences.

Dilution to one to ten of the original concentration with ultrapure deionized water resulted in a 44% spike recovery. By applying the method of standard additions to the diluted sample, using 0.05, 0.10 and 0.15 mg/L increments, a result of 0.1 mg/L for Lead was obtained. (The limit of detection for Lead in the diluted sample was 0.1 mg/L).

Sincerely,

A. Brent Torgensen
A. Brent Torgensen
Section Manager

/clc


SAMPLE NO.
LEAD BY METHOD OF STANDARD ADDITIONS
300
200
100
ABSORBANCE
ACTUAL VALUE
.05
.10
.15
.20
CONCENTRATION (S) mg/l

APPENDIX H

REFERENCES

REFERENCES

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Robson, S.G., Wacinski, A., Zawistowski, S., and Romero, J.C., 1981, Geologic Structure, Hydrology, and Water Quality of the Laramie-Fox Hills Aquifer in the Denver Basin, Colorado. U.S. Geological Survey Hydrologic Atlas, HA-650.

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_____, 1982, Test Methods for Evaluating Solid Waste. SW-846, 2nd edition.

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APPENDIX I

BIOGRAPHIES OF KEY PERSONNEL

Curriculum Vitae

KENNETH J. STIMPFL

Title Partner

Expertise
Environmental Analysis
Impact Assessment
Site and Route Selection
Aquatic Ecology

Experience With Firm
Principal-in-Charge/Project Director

- Review of permits and plant operations for regulatory compliance at four chemical plants in the midwest.
- Hydrological and aquatic ecological assessment and hearing testimony in support of petition for a variance from water quality standards.
- Technical project planning, hazardous waste, field investigations, feasibility studies and clean-up strategies for U.S. Air Force facilities in Alaska, Idaho, Colorado, Nevada, Arizona and New York.
- Site selection and evaluation study for additions to existing fossil power plants, Michigan.
- Environmental assessment, permits and hearing for a new manufacturing plant in Michigan.
- Environmental baseline studies for a fossil-fueled power plant, Michigan.
- Environmental and geohydrological assessment of inactive industrial waste site, Michigan.
- Geohydrological assessment of chemically contaminated site, Michigan.
- Environmental assessment and defense in litigation for oil well development, Michigan.
- Environmental and engineering evaluation of manufacturing plant sites in Iowa, Indiana, Missouri, Michigan, Wisconsin, and Ontario.
- Ecological assessment of potential chemical contamination in the Menominee River, Wisconsin.
- Environmental assessment, preliminary containment design, and negotiation of consent judgment with state and federal agencies for a contaminated chemical plant site, Michigan.
- Site selection study for a new fossil or nuclear power plant, Michigan.
- Preparation of a regulatory compliance plan for a proposed synfuels project, Illinois.
- Radiation survey, assessment, decontamination and health physics monitoring for NRC release of contaminated plant site, Michigan.
- Wetland assessment, development of alternative layouts and agency negotiations regarding a denied 404 permit for a dock in Wisconsin.
- Assessment of environmental enhancement potential through selective dredging of the Little Calumet River for the Chicago District, Corps of Engineers.
- Assessment of potential economic impacts from a proposed regulation to ban landfill disposal of chlorinated solvents for the Illinois Department of Energy and Natural Resources.
- Assessment of aquatic impacts and effects on low-level hydroelectric potential for a variety of proposed dam modifications on the Fox River for the Chicago District, Corps of Engineers.

Project Manager

- Aquatic ecology baseline study and impact assessment for nuclear power plant in Wisconsin, Wisconsin Electric Power Company.
- Environmental baseline studies and impact assessment for copper/zinc mine in Wisconsin, Exxon Minerals Company.
- Power plant site selection study.

Past Experience

Sargent & Lundy Engineers, Chicago, Illinois

- Power plant site selection and evaluation studies in Illinois, Iowa, Wisconsin, Indiana, and studies in Illinois, Iowa, Wisconsin, Indiana, and Oklahoma.
- Ecological baseline studies and impact assessments for thirteen fossil and nuclear power plants.
- Impact assessment, route selection and evaluation of alternative designs for transmission line in West Virginia.
- Evaluation of alternate cooling systems for nuclear power plant.

Faculty Appointment, Indiana University

Assistant Professor of Zoology, Colorado State University

Academic Background

B.S., zoology, Northern Illinois University
M.S., zoology, Colorado State University
Ph.D., limnology, Indiana University

Professional Affiliations

Ecological Society of America; American Society of Limnology and Oceanography; National Association of Environmental Professionals; Societas Internationalis Limnologiae; Illinois Association of Environmental Professionals; Consulting Engineers Council of Illinois

Registration

Certified senior ecologist (Ecological Society of America)

Publications

Numerous technical reports, environmental assessments and environmental reports.

* * *

Curriculum Vitae

RICHARD H. PEARL

Title

Senior Hydrologist/Associate

Expertise

Hydrogeological Investigations
Environmental Assessments

Experience With Firm

Responsible for technical management of hydrogeological investigations, ground-water contamination studies, and water quality evaluations for industrial and government clients. Joined Dames & Moore in 1985.

Senior Hydrogeologist/Associate

- Installation and monitoring of ground-water wells at a petrochemical company in Illinois in compliance with Resource Conservation and Recovery Act regulations.
- Assistance to Shell Oil Co. in obtaining an alternative concentration limit permit under the Resource Conservation and Recovery Act for a refinery in Illinois.

Past Experience

A total of twenty-three years experience in water resources, environmental hydrogeological assessments, and energy development with a private consulting firm, state and federal geological surveys and agencies, and an oil company.

President/Chief Hydrologist, R. H. Pearl and Associates, Denver, Colorado (1983-1985)

- Hydrogeological assessment for a high-level nuclear waste storage project in Washington and Oregon.
- Regional and local hydrogeological investigations in Colorado for confidential clients.
- Formulation of a water quality data base for a confidential client in Colorado.
- Environmental assessment for an oil well development in South Dakota.
- Hydrogeological assessment to assist with mined land reclamation permitting in Colorado.
- Environmental assessment for a strip coal mine development in Washington.
- Hydrogeological investigations and assessment to assure compliance with state regulations for condominiums in Colorado.
- Water capacity, geological and topographical survey for construction of a proposed low-generation power storage unit in western Colorado.

Chief of Ground-Water/Geothermal Section, Colorado Geological Survey (1970-1983)

- Hydrogeological and environmental assessments of solid waste sites in Colorado.
- Regional and local hydrogeological investigations for confidential clients.
- Hydrogeological assessment for the Lowry Landfill in Colorado.
- Environmental and hydrogeological assessment at the Rocky Mountain Arsenal in Colorado.
- Hydrogeological water quality investigations for government agencies in Colorado, Kansas and Wyoming.
- Formulation of water quality data bases for various government clients.
- Decontamination studies for a gasoline-polluted aquifer in Colorado.
- Hydrogeological investigations of oil brine disposal ponds in Colorado.
- Engineering geological investigations for highways and buildings in Colorado.
- Hydrogeological assessment investigations for new subdivisions in Colorado.
- Geothermal resource investigations in Colorado.

- Regional hydrogeological investigations in cooperation with state agencies in Colorado, Kansas and Wyoming to assess ground-water resources.
- Geophysical investigations to delineate geothermal resources in Colorado.

Hydrologist, U.S. Geological Survey, Wyoming and Kansas (1965-1970)

- Regional and local hydrogeological investigations.
- Hydrogeological water quality investigations in conjunction with other government agencies.

Petroleum Geologist, Sunray DX Oil Company, Denver (1963-1965)

- Subsurface geological exploration.

Hydraulic Engineer, Colorado Water Conservation Board (1958-1961, 1962-1963)

- Engineering geological investigations for dam sites in Colorado.
- Surface water availability studies in Colorado.

Academic Background M.A. (1963), geology, University of Missouri
B.A. (1958), geology, University of Colorado

Citizenship United States

Countries Worked In United States

Language Proficiency English

Professional Affiliations Geological Society of America; Colorado Ground-Water Association; American Water Resources Association; Rocky Mountain Association of Geologists; American Institute of Professional Geologists; Association of Ground-Water Scientists and Engineers; National Water Well Association.

Registrations Certified professional geologist: American Institute of Professional Geologists (1971)

Publications Numerous technical and environmental reports in the geoscience field.

† † †

Curriculum Vitae

RICHARD L. HARLAN

Title	Senior Hydrogeologist
Expertise	Ground Water Hydrology Environmental Studies

Experience With Firm

Senior Hydrogeologist

- o Directed hydrologic studies for proposed open-pit mine in northwestern Alaska which included the assessment of water-supply alternatives, transportation corridors, and tailings disposal sites.
- o Managed ground-water program which included computer modeling to assess the probable impacts of Exxon's proposed East Texas Project on ground-water resources for preparation of third party EIS.
- o Principal Investigator for ground water on projects in Colorado, New Mexico and Utah to assess the engineering feasibility and environmental acceptability of alternatives for stabilization of uranium mill tailings from inactive processing sites.
- o Supervision of ground water investigations for proposed and operating open-pit and underground mines in Colorado, Utah, Wyoming, Texas, and Nova Scotia.
- o Principal investigator for surface and ground water evaluations including water resource evaluations for oil shale development in western Colorado, siting studies for the location of thermal power plants, and methanol conversion and coal gasification facilities, and environmental impact assessments for proposed open-pit and underground mines and industrial and residential developments.
- o Managed ground water investigations on potential contamination problems associated with mine wastes, seepage from industrial land fills, uranium tailings ponds, evaporation ponds and ash disposal areas. Also directed studies on surface water and ground water contamination, including containment and recovery of contaminants on industrial sites in Colorado, California, Washington and Pennsylvania.
- o Participated in planning and coordination of complex multidisciplinary teams composed of geologists, hydrologists, biologists, engineers, meteorologists and land-use specialists.

Past Experience

Senior Hydrogeologist, Hardy Associates (1978) Ltd.

- o Prepared surface-water and ground-water components of the Environmental Impact Assessment in support of the proposed Alsands Oil Sands Project in northern Alberta. Also appeared as expert witness and provided testimony in support of the EIS at public hearings.

- o Directed hydrologic and ground water studies for proposed Arctic Gas Pipeline Project which included the Alaskan and Yukon North Slopes and the Mackenzie River Valley.
- o Directed surface and ground water investigations and environmental impact assessments for open-pit mines including oil sands developments in western Canada.
- o Development of dewatering specifications for open-pit mining and deep excavations.
- o Design of pressure relief wells and drainage systems for slope stabilization.
- o Water availability assessments and water supply development.

Research Hydrologist, Environment Canada

- o Major research program involving both theoretical and field investigations of coupled heat-fluid transport in frozen soils, permafrost hydrology and the mechanisms of ground water recharge.
- o Land use and watershed studies.
- o Evaluation of hydrologic effects of forest cutting and studies of snowmelt and streamflow generation processes in mountainous terrain.

Academic Background	B.A., University of Colorado, 1961 M.S., Michigan State University, 1964 Ph.D., Michigan State University, 1967
Professional Affiliations	Association of Professional Engineers, Geologists and Geophysicists of Alberta; American Geophysical Union
Publications	Author of Several Reports Concerned with Coupled Heat-Fluid Transport in Porous Media, Permafrost Hydrology and Ground Water
Registration	Professional Geologist, Alberta

Curriculum Vitae

LAWRENCE EDWARD COPE

Title	Hydrogeologist
Expertise	Ground Water Hydrology, Geology
Experience with Firm	o Participated in soil and ground water investigations on potential industrial contamination sites in Colorado, Wyoming, and Nebraska. Work included drilling supervision, ground water sampling, and aquifer testing and analysis. o Supervised drilling, well completion, and ground water sampling activities at a hazardous waste site in Colorado. o Project coordinator for industrial plant site selection study in Wyoming. Also project staff member on various environmental assessment and site selection studies in the western United States. o Field geologist sampling and logging soils for foundation engineering studies in Montana. o Field geologist on gold placer explorations projects in Wyoming and Amazon Basin, Brazil.
Past Experience	o Staff hydrologist for an earth sciences and engineering consulting company. Involved with ground water investigation for proposed in-situ uranium mine in Wyoming. Also involved with dewatering control system design for open-pit lignite mine in Mississippi. o Assistant hydrologist for U.S. Geological Survey, Water Resources Division, Nuclear Hydrology Department. Member of research team studying hydrologic suitability of proposed site as a nuclear waste repository. Work included design and implementation of downhole instrumentation package and data acquisition system, laboratory testing of system, and computer analysis and presentation of data.
Academic Background	B.A., Earth Sciences, University of Colorado, Boulder, 1978
Professional Affiliations	National Water Well Association Colorado Ground Water Association

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Curriculum Vitae

M. CAROL MC CARTNEY

Title	Project Hydrogeologist
Expertise	Hydrogeology Glacial Stratigraphy and Geomorphology Environmental Geology Regulatory Analysis and Liaison Environmental Data Base Management
Experience with Firm	o Investigation of ground water contamination at U.S. Air Force bases. o Creation of computer data base to display air pollution/emissions data.
Past Experience	Environmental Scientist, Wisconsin Power & Light Company o Managing contracts with consulting firms in air and water quality monitoring programs. o Interpreting technical reports on air and water quality for company management. o Acting as company liaison to technical staff of state and federal regulatory agencies. o Observing and participating in air and ground water quality laws and rules development in Wisconsin. o Reviewing and interpreting environmental laws and regulations for effect on company's policy, actions, and position papers. Hydrogeologist, Residuals Management Technology, Inc. o Design and implementation of water quality monitoring programs at mining, industrial, and hazardous waste land disposal sites and hazardous waste treatment facilities. o Directed studies and field investigations to determine the feasibility of initiating landfill operations at new sites, and expanding operations at existing sites. o Conducted screening studies to find landfill sites to meet environmental regulations for industrial and mining waste.
Academic Background	B.A., Geology, University of Colorado, Boulder, 1973 M.S., Geology, University of Wisconsin, Madison, 1976 Ph.D., Geology, University of Wisconsin, Madison, 1979
Professional Affiliations	American Water Resources Association, Wisconsin Section, President-elect, 1984-85 Certified Soil Tester, State of Wisconsin Sigma Xi
Publications	Author of technical papers and maps on glacial deposits and glacial history in Wisconsin.

ch-tr

Curriculum Vitae

CAROL JEAN SCHOLL

Title	Staff Geologist
Expertise	Geology Ground Water Hydrology

Experience with Firm

Staff Geologist, 1983-

- o Managed hazardous waste field investigation at United States Air Force (USAF) facility, Illinois. The program involved the analysis and evaluation of hazardous materials in soil and ground water including fuels, solvents, and trace metals.
- o Analyzed data, prepared reports, reviewed audits, and designed field investigations for numerous USAF hazardous waste studies.
- o Dames & Moore's Group Contact Coordinator for the Electric Power Research Institute's Seismic Risk Hazard Analysis Program, Region 2.
- o Prepared responses to questions posed by the NRC concerning faulting studies for a nuclear power plant in southern Indiana.

Assistant Geologist, 1973-1975

- o Assisted in the compilation and reduction of ground water data for PSARs for three nuclear power plant sites (NPPS).
- o Participated in detailed field structural geological studies of a NPPS in Pennsylvania.
- o Performed geological and ground water investigations of a NPPS contaminated by industrial wastes.
- o Performed engineering geological duties during rock coring and soil sampling program at a NPPS in northwestern Illinois.
- o Assisted in reduction of ground water data for a hydrologic study of a proposed coal strip mine in eastern Montana.

Past Experience

Head: Group Programs, Field Museum of Natural History, Chicago

- o Supervised professional and clerical staff members of a division of the Department of Education.
- o Participated in planning and decisions regarding departmental policies, budgets, and procedures.

Instructor of Geology, Field Museum of Natural History, Chicago

- o Instructed school groups, adult volunteers, and other adult groups in geology in the museum.
- o Trained adult volunteers to present geology tours.
- o Supervised a manned exhibit featuring a hands-on environment of natural history specimens.

Past Experience (cont'd)	Miami University, Oxford, Ohio o Graduate Teaching Fellow and Associate. o Graduate Teaching Assistant.
Academic Background	Course work toward Ph.D., with emphasis on Geochemistry and Mineralogy, Miami University, Oxford, Ohio M.S., Geology, 1970, Miami University, Oxford, Ohio B.S., Geology, 1966, Kent State University, Kent, Ohio
Citizenship	American
Countries Worked In	United States
Language Proficiency	English
Professional Affiliations	American Association for the Advancement of Science Mineralogical Society of America National Water Well Association

nh-tl

Curriculum Vitae

STEVE A. WERNER

Title	Ground Water and Geotechnical Assistant
Expertise	Ground and Surface Water Hydrology
Experience with Firm	o Field Supervisor of drilling, well installation, and sampling for hazardous waste contamination investigations in Utah and Colorado. o Conducted ground and surface water sampling for Durango UMTRAP (Uranium Mill Tailings Remedial Action Program) project. o Assisted in supervision of drilling and development of ground water monitoring for Durango UMTRAP project. o Assisted in geotechnical drilling for Durango UMTRAP project. o Assisted in field soils evaluations for Durango UMTRAP project. o Conducted all radiological sampling for Durango UMTRAP project. o Conducted all meteorological data collection for Durango UMTRAP project. o Field installation of all environmental monitoring sites.
Academic Background	B.S., Genetics, University of Utah (emphasis in Radiological Sciences)

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APPENDIX J

SAFETY PLAN

DAMES & MOORE
HEALTH AND SAFETY PLAN

Project Name and Number: Phase IIb Environmental Investigation (01016-216-07)

Project Site Location: Lowry Air Force Base, Colorado

Field Supervisor: Richard L. Harlan

On-Site Safety Officer:

Plan Preparer: Michael W. Ander

Plan Reviewer: Kim Petschek

Preparation Date: April 18, 1984

Plan Approvals:

Project Safety Coordinator

Michael W. Ander (date)

Managing Principal-in-Charge

George W. Nicholas (date)

Field Supervisor

Richard L. Harlan (date)

I. PURPOSE

The purpose of this Plan is to assign responsibilities, establish personnel protection standards, specify mandatory operating procedures, and provide for contingencies that may arise while operations are being conducted at the site.

II. APPLICABILITY

The provisions of the Plan are mandatory for all on-site Dames & Moore employees and subcontractors engaged in hazardous material management activities including but not limited to initial site reconnaissance, preliminary field investigations, mobilization, project operations, and demobilization.

III. RESPONSIBILITIES

A. Field Supervisor

The FS shall direct on-site investigation and operational efforts. At the site, the FS, assisted by the on-site Safety Officer, has the primary responsibility for:

1. Assuring that appropriate personnel protective equipment is available and properly utilized by all on-site personnel.

2. Assuring that personnel are aware of the provisions of this plan, are instructed in the work practices necessary to ensure safety, and in planned procedures for dealing with emergencies.

3. Assuring that personnel are aware of the potential hazards associated with site operations (see Tables 1 and 2).

4. Monitoring the safety performance of all personnel to ensure that the required work practices are employed.

5. Correcting any work practices or conditions that may result in injury or exposure to hazardous substances.

6. Preparing any accident/incident reports (see attached Accident Report Form).

7. Assuring the completion of Plan Acceptance and Feedback forms attached herein.

B. Project Personnel

Project personnel involved in on-site investigations and operations are responsible for:

1. Taking all reasonable precautions to prevent injury to themselves and to their fellow employees.

2. Implementing Project Health and Safety Plans, and reporting to the FS for action any deviations from the anticipated conditions described in the Plan.

3. Performing only those tasks that they believe they can do safely, and immediately reporting any accidents and/or unsafe conditions to the FS.

IV. BACKGROUND

Based on preliminary site evaluations of Lowry Air Force Base, Colorado, there appear to be four (4) areas that may have generated significant environmental contamination over the lifetime of the facility. Suspected contaminants have been identified; quantification awaits future investigation based on sampling and analysis. Dames & Moore anticipates that site conditions are such that only relatively low levels of contaminants may be encountered during the proposed drilling and soil and water sampling.

Sites FT-1 and FT-2, Fire Training Areas No. 1 and No. 2 — These areas have been used for training purposes from 1946 to 1965 and from 1965 to 1980, respectively. Practice fires were set on the ground or in old aircraft by burning waste oils, waste solvents, fuels, paint thinners, and sludge. During the period 1946 to 1960, fire training exercises were conducted 4 to 5 times per day, 5 days per week, in which each exercise utilized 500 to 1000 gallons of contaminated waste materials and JP-4 fuel.

Sites D-1, D-2, and T-1, Sanitary Landfill Zone — This area has been in use from 1948 to 1983, and materials disposed of include general refuse, waste construction rubble, waste solvents, spent acid, empty pesticide containers, and cutting oils.

Site SP-1, Old Jet Fuel Yard Area — This was the location of numerous small spills of jet fuel in the 1950s and early 1960s during loading and unloading of aircraft.

Site S-5, Auto Hobby Shop — The waste oil reservoir was believed to have been overfilled at an undetermined time, generating a local spill problem.

A. Dames & Moore Activity

Dames & Moore will drill soil borings at the Fire Training Areas, the Old Jet Fuel Yard Area, and the Auto Hobby Shop and collect soil samples. Monitoring wells will be installed near the Landfill Site and the Fire Training Areas and the Old Jet Fuel Yard. Water samples will be collected from these wells.

B. Suspected Hazards

Suspected hazards are presented in as much detail as is currently available. These are: POL (waste petroleum, oils, and solvents) products, JP-4 fuel, unknown acids, and pesticides.

V. EMERGENCY CONTACTS AND PROCEDURES

Should any situation or unplanned occurrence require outside or support services, the appropriate contact from the following list should be made:

Agency	Person to Contact		Telephone
D&M Field Supervisor	R. Harlan	(office)	303-232-6262
		(home)	303-988-2366
D&M Industrial Hygiene and Safety Director	K. Petschek	(office)	914-761-6323
		(home)	212-724-6414
Police			
Fire			
Ambulance			
Hospital			
Command Post			

In the event that an emergency develops on site, the procedures delineated herein are to be immediately followed. Emergency conditions are considered to exist if:

- o Any member of the field crew is involved in an accident or experiences any adverse effects or symptoms of exposure while on scene.
- o A condition is discovered that suggests the existence of a situation more hazardous than anticipated.

The following emergency procedures should be followed:

a. In the event that any member of the field crew experiences any adverse effects or symptoms of exposure while on scene, the entire field crew should immediately halt work and act according to the instructions provided by the Field Supervisor.

b. The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated should result in the evacuation of the field team and reevaluation of the hazard and the level of protection required.

c. In the event that an accident occurs, the FS is to complete an Accident Report Form for submittal to the MPIC of the office, with a copy to the Health and Safety Program Office. The MPIC should assure that followup action is taken to correct the situation that caused the accident.

VI. MONITORING METHODS AND PROTECTION REQUIRED

Monitoring Methods, Action Levels and Protective Measures

Methods for monitoring for suspected contaminants, action levels, and protective measures to be used for various contaminant concentration levels are presented in Table 1.

Protective Equipment Required for On-Site Activities

The protective equipment required may vary, depending on the concentrations and dispersion of contaminants encountered during each phase of the work. Table 2 specifies protective equipment required for each on-site activity.

FORM #IHST-1

REVIEW RECEIPT

PROJECT HEALTH AND SAFETY PLAN

Instructions: This form is to be completed by each person to work on the site and returned to the Program Director-Industrial Hygiene and Safety.

Job No. 01016-216-07

Project: Lowry Air Force Base, Colorado

Rev. No. 0 Date 04/18/84

I represent that I have read and understand the contents of the above plan and agree to perform my work in accordance with it.

____
Signed

____
Date

TABLE 1

HAZARD MONITORING METHOD, ACTION LEVELS, AND PROTECTIVE MEASURES

Hazard	Monitoring Method	Action Level	Protective Measures
Toxic atmosphere	HNU continuous recorder	>5 units	Don respirator. See Table 1 for exposure standards.

TABLE 2

PROTECTIVE EQUIPMENT

Level	Protective Equipment	Criteria for Use
C	Full-face respirator with air-purifying cartridges for gas/dusts Disposable coveralls Rubber boots Hard hat with splash shield or safety glasses/goggles Nitrile gloves	When drilling or sampling where dusts become airborne, when organic odors are noticeable, or as indicated by HNU.
D	Rubber boots Disposable coveralls (optional) Nitrile gloves Safety glasses or goggles Hard hat	During sampling activities other than those mentioned above

ATTACHMENT 1

PROTECTIVE EQUIPMENT

I. INTRODUCTION

When field investigation activities are conducted where atmospheric contamination is known or suspected to exist, where there is a potential for the generation of vapors or gases, or where direct contact with toxic substances may occur, equipment to protect personnel must be worn. Respirators are used to protect against inhalation and ingestion of atmospheric contaminants. Protective clothing is worn to protect against contact with and possible absorption of chemicals through the skin. In addition to protective clothing and respiratory protection, safe work practices must be followed. Good personal hygiene practice prevents ingestion of toxic materials.

Personnel equipment to be used has been divided into two categories commensurate with the degree of protection required, namely Levels C and D protection.

II. LEVELS OF PROTECTION

A. Level C

1. Personal Protective Equipment

- Air-purifying respirator (MSHA/NIOSH approved)
- Disposable chemical resistant coveralls
- Gloves, outer, working gloves
- Gloves, inner, chemical resistant
- Boots, steel toe and shank
- Hard hat (face shield)
- Rubber boots, outer, chemical resistant (disposable)

2. Criteria for Selection

a. Air concentrations of identified substances are such that reduction to at or below the substance's exposure limit is necessary and the concentration is within the service limit of the cartridge.

b. Atmospheric contaminant concentrations do not exceed the Immediately Dangerous to Life or Health (IDHL) levels.

c. Contaminant exposure to unprotected areas (head and neck) are within skin exposure guidelines, or dermal hazards do not exist.

d. Job functions have been determined not to require a higher level of protection.

B. **Level D**

1. **Personal Protective Equipment**

- Coveralls
- Boots/shoes, safety or chemical resistant, steel toe and shank
- Boots, outer (chemical resistant disposables)
- Hard hat (face shield)
- Gloves

2. **Criteria for Selection**

a. No indication of any atmospheric hazards.

b. Work function precludes dusting, splashes, immersion, or potential for exposure to any chemicals.

3. **Guidance on Selection Criteria**

a. Level D protection is primarily a work uniform and should not be worn in any area where the potential for contamination exists.

b. In situations where respiratory protection is not necessary, but site activities are needed, chemical resistant garments — high quality or disposable — must be worn.

III. RESPIRATORY PROTECTION

The following procedures should be used for respiratory protection:

A. Inspect all washers, diaphragms, and facepiece-to-face seal area for any tears, pinholes, deformation, or brittleness. Should any of these exist, use a different respirator.

B. Place the respirator on the face, tighten and use both a positive and a negative pressure test, prior to entering the site, to assure a proper fit. Checking for proper fit involves the following:

1. **Negative Pressure Test**

Close off the inlet opening of the cartridge or the breathing tube by covering it with the palm of the hand or by replacing the tap seal. Gently inhale so that the facepiece collapses slightly, and hold the breath for 10 seconds. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is satisfactory.

2. Positive Pressure Test

Remove the exhalation valve cover. Close off the exhalation valve with the palm of the hand. Exhale gently so that a slight positive pressure is built up in the facepiece. If no outward leakage of air is detected at the periphery of the facepiece, the face fit is satisfactory. (Note: With certain devices, removal of the exhaust valve cover is very difficult, making the test almost impossible to perform.)

ATTACHMENT 2

DAMES & MOORE STANDARD OPERATING PROCEDURES

WORK PRACTICES

1. Smoking, eating, drinking, and chewing tobacco are prohibited in the contaminated or potentially contaminated area.

2. Avoid contact with potentially contaminated substances. Do not walk through puddles, pools, mud, etc. Avoid, whenever possible, kneeling on the ground, leaning or sitting on equipment or ground. Do not place monitoring equipment on potentially contaminated surface (i.e., ground, etc.).

3. All field crew members should make use of their senses (<u>all senses</u>) to alert them to potentially dangerous situations (i.e., presence of strong and irritating or nauseating odors).

4. Prevent, to the extent possible, spillages. In the event that a spillage occurs, contain liquid if possible.

5. Prevent splashing of the contaminated materials.

6. Field crew members shall be familiar with the physical characteristics of investigations, including:

   - wind direction
   - accessibility to associates, equipment, vehicles
   - communication
   - hot zone (areas of known or suspected contamination)
   - site access
   - nearest water sources

7. The number of personnel and equipment in the contaminated area should be minimized consistent with site operations.

8. All wastes generated during D&M and/or subcontractor activities on site should be disposed of as directed by the Field Activity Leader.

HALF-FACE RESPIRATORS

INSPECTION PROCEDURE

1. Look for breaks or tears in the headband material. Also stretch to check the elasticity.

2. Make sure all headbands, fasteners, and adjusters are in place and not bent.

3. Check the facepiece for dirt, cracks, tears, or holes. The rubber should be flexible, not stiff.

4. Look at the shape of the facepiece for possible distortion that may occur if the respirator is not protected during storage.

5. Check the exhalation valve located near the chin between the cartridges by the following:

   - Unsnap the cover;

   - Lift the valve and inspect the seat and valve for cracks, tears, dirt, and distortion; and

   - Replace the cover. It should spin freely.

6. Check both inhalation valves (inside the cartridge holders). Look for same signs as above.

7. Check the yoke for cracks.

8. Make sure the cartridge holders are clean. Make sure the gaskets are in place and the threads are not worn. Also look for cracks and other damage.

9. Check the cartridges for dents or other damage, especially in the threaded part.

DONNING PROCEDURE

1. Screw the cartridge into the holder hand-tight so there is a good seal with the gasket in the bottom of the holder, but don't force it. If the cartridge won't go in easily, back it out and try again.

   Always use cartridges made by the same manufacturer who made the respirator.

2. Place the facepiece over the bridge of your nose and swing the bottom in so that it rests against your chin.

3. Hold the respirator in place and fasten the top strap over the crown of your head.

4. Fit the respirator on your face and fasten the strap around your neck. Don't twist the straps. Use the metal slide to tighten or loosen the fit, but not too tight.

5. Test the fit by:

   - Lightly covering the exhalation valve with the palm of your hand. Exhale. If there is a leak, you will feel the air on your face.

   - Covering the cartridges with the palms of your hands. Again, don't press too hard. Inhale. The facepiece should collapse against your face.

   - If there is a leak with either test, adjust the headbands or reposition the facepiece and test until no leakage is detected.

SANITIZING PROCEDURE

1. Remove all cartridges, plugs, or seals not affixed to their seats.

2. Remove elastic headbands.

3. Remove exhalation cover.

4. Remove speaking diaphragm or speaking diaphragm/exhalation valve assembly.

5. Remove inhalation valves.

6. Wash facepiece and breathing tube in cleaner/sanitizer powder mixed with warm water, preferably at 120° to 140°F. Wash components separately from the facemask, as necessary. Remove heavy soil from surfaces with a hand brush.

7. Remove all parts from the wash water and rinse twice in clean warm water.

8. Air dry parts in a designated clean area.

9. Wipe facepieces, valves, and seats with a damp lint-free cloth to remove any remaining soap or other foreign materials.

PLAN FEEDBACK FORM

Problems with plan requirements:

Unexpected situations encountered:

Recommendations for future revisions:

PLEASE RETURN TO THE FIRMWIDE HEALTH AND SAFETY OFFICE - WP

ACCIDENT REPORT FORM

SUPERVISOR'S REPORT OF ACCIDENT	DO NOT USE FOR MOTOR VEHICLE OR AIRCRAFT ACCIDENTS
TO	FROM TELEPHONE (include area code)
NAME OF INJURED OR ILL EMPLOYEE	

DATE OF ACCIDENT	TIME OF ACCIDENT	EXACT LOCATION OF ACCIDENT

NARRATIVE DESCRIPTION OF ACCIDENT

NATURE OF ILLNESS OR INJURY AND PART OF BODY INVOLVED

LOST TIME YES ☐ NO ☐

PROBABLE DISABILITY (check one)

FATAL	LOST WORK DAY WITH __ DAYS AWAY FROM WORK	LOST WORK DAY WITH __ DAYS OF RESTRICTED ACTIVITY	NO LOST WORK DAY	FIRST AID ONLY
☐	☐	☐	☐	☐

CORRECTIVE ACTION TAKEN BY REPORTING UNIT

CORRECTIVE ACTION THAT REMAINS TO BE TAKEN (by whom and by when)

NAME OF SUPERVISOR	TITLE
SIGNATURE	DATE

END
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